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FastTrack

YOUR HANDY GUIDE TO EVERYDAY TECHNOLOGY

To Augmented Reality

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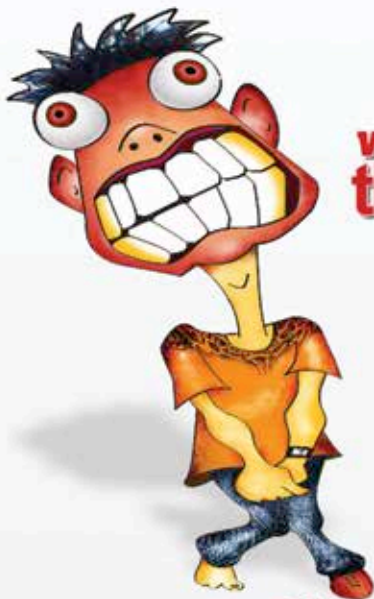


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- Introduction to AR and how is it different from Virtual Reality?
- Notable achievements, companies involved in this space
- Different types of Augmented Reality
- AR: The Limitless Possibilities
- Hardware: Display types, Input devices, Tracking devices
- How does AR work?
- 30 best AR Apps for your mobile device
- Coding for AR - An introduction



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AUGMENTED REALITY

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AR programming is neither just about mathematics nor just about code. There are hurdles and we are here to help you take a jump into creating AR apps

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Introduction

“Reality is merely an illusion, albeit a very persistent one.”

– Albert Einstein

Given that exquisite premise by Mr. Einstein, consider this for a moment: what would happen if you add to that illusion? Would the result be more illusory or more real? Before our minds implode under the weight of the conundrum, let's get down to what we want to talk about – Augmented Reality.

Augmented reality (AR) is the altering your perception of the world by wrapping a layer around reality. A layer of augmentation. They say reality is a hard pill to swallow. So how about reality served with a sugar coating of information? Augmented Reality can help in multiple ways – provide critical information about your surroundings, give you your personal babel fish, help soldiers survive wars better, help law enforcement officials catch criminals, avoid car accidents, train surgeons, and much more. But AR is not just about this, it can be fun too! Yep it has limitless possibilities in gaming

This FastTrack will take you into the world of Augmented Reality on a magic carpet ride of sorts. We first begin by introducing you to the key concepts and also differentiate AR from another closely related concept – Virtual Reality. Next we tell you about the earliest attempts at augmentation in the form of Experience Theaters to newer milestones like Google Glasses. We also try to chronicle some of the pivotal moments in this space.

The most notable (and famous) implementation of AR, as of now, are the location browsers running on mobiles that help you locate points of interest around you. As you read this FastTrack, you'll be surprised to learn that (metaphorically) AR is much larger than what a mobile phone can accommodate. You would learn its various uses and types.

We do not stop there and we don't want you to either. We explore the significance of AR and how it is set to change the world as we see it. We show

you how you have already been using this technology and what makes it tick; the various displays and sensors that enable it.

Should you be interested in not just experiencing AR but also creating that same magic, the last chapter will help you take your first steps into AR programming. We tell you about the domain knowledge required for starting off with each type of AR implementation and we end with an introduction to some of the most useful frameworks / toolkits available to begin your journey.

As always, happy reading. 

CHAPTER #1



WELCOME TO AUGMENTED REALITY

Change your perception of reality
by understanding this fascinating
technology. How different is it from
Virtual Reality? Read on to find out

We live in a world where distinguishing between fact and fiction is increasingly becoming difficult. In fact the lines are blurring so much that “reality” is a saleable product now. Don’t believe us? Look around you - heard of a little

concept called Reality TV? An entertainment sham that people buy into irrespective of whether there is any semblance of reality in what is being watched. But of course we digress. When focusing on reality in technology, there are a few occasions where your reality is blurred. Everytime you play a game for instance. You get so immersed in the game that your surroundings dissolve, you almost enter that virtual world and when someone calls out for you from the “real” world you return to it with a jolt. Almost resultantly, if we might add. There are technologies out there that blur your reality at varying levels. Some embellish what you experience while some completely immerse you into an alternate reality. Augmented reality is just one of those realities at sale.

What is augmented reality anyway?

If you’ve been a Digit reader for long, you might already know what the word ‘augmented’ means. But just in case you’re not, let us try to break it down for you – the word ‘augmented’ means enhanced or increased. Simple enough right? The phrase simply means “enhanced reality”.

But if reality is what it is how does someone enhance or embellish it? By using a tool such as your smartphone. The concept of augmented reality revolves around adding more information to your world (or let’s say just your view of the world). The augmentation is usually done by adding extra data to the perception of things around us which are not visible normally. Let us say you are walking down the road (let’s assume, in a city where you have never been) and you see a fenced and open area but it doesn’t have a signboard demarcating the plot. You check on your phone and Google maps says that the area is a meditation center. See? How your mobile phone enhanced your perception of your world?

The above was a mere example to show how everyday tools help us get more out of our reality. But before you grasp the above example as one of augmented reality, it’s best we tell you that Google maps does not really come under the umbrella of augmented reality.

Imagine again, you go to Shanghai, a well known city in China. What you are looking for is a vegetarian restaurant but since everything is written in chinese which you do not understand, you are unable to figure out where to go. You take out your smartphone, connect to the internet and launch an app. This app looks through the rear camera and shows you what it sees except there’s more than just the actual scene. You point it to a building, and it shows a graphical callout that says “hotel” next to



Image source: Wikipedia

Figure 1: An application of augmented reality

the building, you point it to a different building and it says it's a non-veg restaurant. Further down the road you see another building marked as a "theater". Now, that is what is augmented reality. Such an app would really be enhancing your perception of reality; it would add information to your reality - it would augment reality.

Another example for visual augmentation would be glasses which tell your the direction in which you are looking. If you are looking towards east, it shows on screen what you are seeing (of course) and in addition, tells you that

you are looking in the 'east' direction (if that is the direction you were facing). This information is displayed on the transparent glass. You turn right by 90 degrees and it would say that you are now facing south. Add 'night vision' view to those glasses and



Figure 2: Augmented reality is not a distant future anymore

you have a tool that can be used on a night safari (or Osama assassination raid) without losing track of direction! In this example, we want to highlight the fact that augmented reality is not dependent on an internet connection. Such a device would work via an inbuilt electronic compass. You'll find out more about exactly how, in the later chapters.

Mediated reality

Just like augmented reality is about enhancing the perception of the world around us by adding more information to it, a mediated reality is about mediating it. Mediation means "coming in between two things to affect an agreement". Here the two things are you and "the reality", well, the 'real' reality for that matter (hence we write it as the reality)!

If you're wondering "Isn't augmented reality the same a mediated reality? After all augmentation too comes in between us and the reality!" The answer is both yes and no. Actually the question is akin to "Isn't Apple and Fruit the same? After all they both grow on trees!". Without further ado, let us see the actual difference.

Mediated reality is a way to alter your perception of your surroundings by adding or removing information from it. Removing is the keyword here. While augmented reality is achieved by adding information to the perception of our surroundings, removing information from surrounding would qualify for mediation as well.

Virtual Reality

Much before augmentation was linked to reality, virtualization was. Virtual reality was a term which has been flashed a lot in recent past. Geeks who love to watch TV channels of the likes of Discovery and National Geographic would have been hearing the term for quite some time now. However, if you were having a vacation on Mars all this while, it would be great to get informed about virtual reality before we proceed further.

The term 'virtual reality' is easily one of the most self-contradicting terms ever coined – an oxymoron, if you will – though it is simple enough to understand. Virtual reality means a 'reality' which 'imaginary'. But understand that this is not just imagination or processes that happen in the mind. It is sensory perception that is induced by tools from the real world. The term refers to simulation of reality in a way that it looks and feels real but is not. Science is pushing boundaries everyday to cover the feeling part well enough.

Virtual reality is a simulation (the virtual part) of some part of real world (the reality part). In most cases known, the simulation is done in either of two ways:

- 1 The subject (person) is sent to a room with giant displays. The picture being displayed on the walls of the screens all around is calibrated with the position where the person is located. This makes the subject see the simulation as if he is watching it for real. The acoustics system is synced well with the environment as well.
- 2 The subject is given wearable gadgets which are synced with each other and allow him to watch an ongoing simulation (video and audio) as if he is watching reality. The wearables also include gloves fitted with sensors to detect movements. Neck and body movements are also detected using other wired or wireless methods. These sensors send signals to the controller which then calculates the scene to be shown. The wearable devices also send feedback to the subject to make his experience more



Figure 3: The two ways of doing VR

real. For instance vibration could be induced on the subjects seat if the scene being viewed is that of a jeep going through a Safari.

Virtual reality is used in a lot of applications such as preliminary training exercises (e.g. for pilots and military) and entertainment. One of the lesser known usage of VR is for therapeutic purposes on psychological levels.

Virtual Reality and Augmented Reality - similarities

It might just seem that virtual reality is very different from augmented reality. After all, they look so different. Virtual reality is all about making you believe that you are in a place where you actually aren't, experiencing sensations that aren't there.

Take for an instance a 3D game that you play on your PC (the likes of Crysis, Need for Speed etc.) You could call some of them to have an immersive gameplay. Bring in a large display (say a 42-inch display) and you can get really lost into the world. In no time you start feeling that every single move in the game is actually happening with you in the real world. Every bullet you shoot and every turn you take feels like happening in real world though none are real. You start living in a reality that does not exist. That is the effect which scientists all around the world have been trying to enhance and as scientific research goes forward, a few things start coming to everyday technology.

A very popular game, Prototype's storyline was set in New York city. Locations, buildings, roads - all were designed into the game. During the gameplay, you run through the streets of the city, climb buildings. Let us assume you are not doing the gameplay on a single screen but a room with all walls as displays which make you believe that you are actually in the gameplay. Wouldn't that be really a great gameplay? You would be totally immersed.

Imagine an extension of this scenario. What if all those people in the game were real? By real we mean graphically generated models of real people right down to the clothes they were wearing. What if each one of those people were similarly plugged into this virtual universe, through virtual reality rooms of their own? The traffic could be created in a way to mimic actual traffic conditions on that day. So it the weather. Such a game wouldn't be so immersive that you would actually forget who you are and where you are?

Would you call that game a game? Or would you call it an application built around the concepts of 'augmented reality'? It's both. In a way Virtual Reality is a higher level of augmentation of reality - it is the peak. In the realms of Virtual Reality, it's not just the information that is added to reality but also control of that virtualised environment.

One of the main uses of virtual reality in the times we live is simulation programs that help train people. For instance, training Pilots. Allowing a newbie to take control of a fighter jet is extremely risky to both life and property and thus, flight simulation is one of the major uses of VR. For a VR flight simulator what could be the factors involved? Well, we'll need a 3D map of the reality and load it on a computer. We'll need to simulate the Aircraft's cockpit right down to the last knob and dial. The sounds that the plane produces right down to the beep, squeak and grid. We would need a pilot's seat and so on. This virtual environment will even need to react

to what is happening for e.g. the seat would need to tilt as the trainee pilot banks the plane and so on.

Go over the scenario and you'll realise that all that happened was augmentation. We took conditions from the real world such as altitude and wind-speed related information and plugged them into the simulation. We enhanced the experience by providing the right type of seat. We added the change in view as the plane would tilt. Virtual reality might not seem all that different.

Virtual Reality and Augmented Reality - difference

All lines between virtual reality and augmented reality are not blurred and hazy, There are certain stark differences:

- 1 Virtual reality can be built around places that do not exist. While we gave an example of Prototype which has been set in Manhattan, there are a plenty of games which are set in totally unreal locations and there is no way you could connect those places to reality. On the other hand, AR is not connected to non-existent worlds. All places on which AR would work (both theoretically and practically) have to exist.
- 2 Virtual reality requires certain setup which allows the experience to be immersive. The concept of VR revolves around building an experience so immersive that the subject (okay, we all hate being subjects, makes us sound like lab rats, but that is how you would find it written in a lot of literature concerning VR) forgets that he is not in the real world and perceives the virtual world as reality instead. Setup usually needs tools built for this purpose such as special glasses, large screens and other wearable gadgets that detect your movements and predict what you are trying to do in the virtual world. AR does not need all that. The concept of AR revolves around enhancing the reality that already exists by adding meaningful information to it.
- 3 Usage of AR almost always requires you to be present at the place where surroundings have to be to augmented.

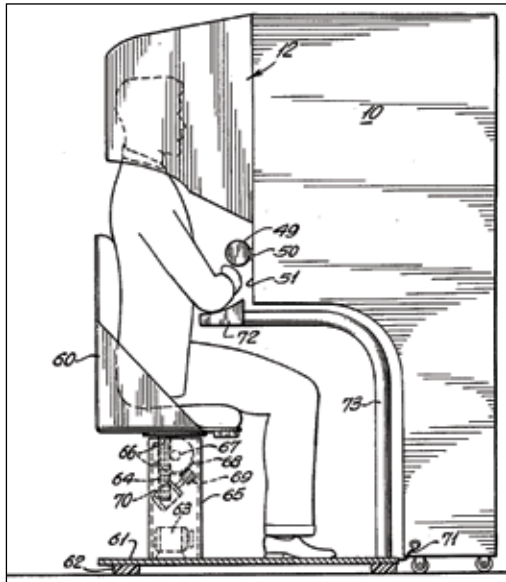
One of the simpler ways to differentiate between VR and AR is that VR is about 'experiencing' a place whether or not it is real. AR is about 'enhancing' the perspective of a place by adding more information to it. All other differences creep in due to the differences in main idea around which they revolve. 



NOTABLE ACHIEVEMENTS IN THIS SPACE

From the earliest attempts at
augmentation in the form of Experience
Theaters to newer milestones like Google
Glasses, we chronicle some of the pivotal
moments in this space

Augmented Reality dates back to the 1950s when Morton Heilig, Father of Virtual Reality, invented the Sensorama Stimulator. He dubbed it the “Experience Theater”. The idea behind it was to simulate an experience with visuals, sound, vibration, and smell, without actually being subjected to the “possible hazards of particular situations”. It was designed as a cinematic experience: it blew wind at you, vibrated the seat you sat on, played sounds to your eyes and projected a form of a stereoscopic 3D environment to the front and sides of your head; kind of like those 5D movies that we watch in theaters today. However, it was a mechanical device shaped like an arcade machine from the 80s. Oddly enough in retrospect, the project didn’t get financial backing. The first augmented reality head-mounted display system was invented by Ivan Sutherland in 1968. The device was too heavy-to-handle and was hung suspended from the ceiling and very appropriately called The Sword of Damocles. While its graphical prowess was fairly limited, it was the first step to usable-AR. It was only in the 1990s that the tech was finally christened, when a Boeing researcher Tom Caudell coined the term “augmented reality”. Julie Martin created a theatrical production in Australia called “Dancing In Cyberspace”, which used Silicon Graphics computers to let the dancers and acrobats manipulate virtual objects in real time projected into the same performance space.



Sensorama Stimulator

For most of the 20th century, AR remained a toy for the scientists. Which meant that the common man didn’t even know it existed. Bulky equipment

with expensive software kept far from the consumer; until Hirokazu Kato of Nara Institute of Science and Technology, Japan released the ARToolKit to the open source community. The ARToolKit was a platform for creating augmented reality applications. It used video tracking capabilities and virtual object interaction, and provided 3D graphics models that could be overlaid on any OS platform. Smartphones were not in the picture at the time; the Flash based AR applications required a simple hand-held device with a camera and a stable Internet connection. Prof. Bruce H. Thomas of the Wearable Computer Lab at the University of South Australia created the first



ARQuake

ever Augmented Reality video game, ARQuake. You needed your laptop in a backpack, GPS, gyroscopes, a head-mounted display and voila! The world around you changed into a game arena, with monsters roaming about in your vicinity in real time. You didn't need a joystick; you could move about in the real world and destroy the virtual monsters. The game still exists as a prototype to this day and unfortunately, no plans to commercialise it exist as of now.

A few years later in 2008, Augmented Reality apps came to your smartphones, where you could finally enjoy this mindblowing technology. With applications like Wikitude and Layar which pioneered the smartphone app market, the environment around you was suddenly made "clickable". These AR apps use your smartphone/tablets' camera, GPS, compass and other sensors to overlay information on the camera feed to your device. When ARToolkit was ported to Adobe Flash, Augmented Reality was made possible through your desktop browser and the webcam.

In February 2009, at the TED conference, Pattie Maes and Pranav Mistry presented their augmented-reality system- SixthSense. Their prototype consisted of a pocket projector, a mirror and a camera contained in a pendant-like device that a user wore around his neck. Since the camera is positioned on the user's chest, it augments everything

in sight. SixthSense is a remarkable device; it uses these off the shelf components and costs approximately \$350 to build (not including the computer). The micro-projector and the camera are connected to a mobile computing device placed in the user's pocket. The mini-projector projects visual images onto your surroundings- walls, hand, table, etc., enabling them to be used as interactive screens. The camera and mirror are used to recognize and track a user's hand gestures, colors and physical objects using image-processing based techniques. The software on the computing device processes the video stream data captured from the camera using simple computer-vision techniques, gathers GPS coordinates and pulls up data from the Internet. The user may also wear colored caps on the fingers which are used to interact with the projected image; even fingers with different colors of nail polish would work. The movements and arrangement of these colored markers (also known as fiducials) and hand gestures serve as interaction instructions for the projected application interfaces. SixthSense also supports multi-touch interaction letting you zoom in, zoom out or pan using many of the intuitive hand movements that we are now familiar with. The SixthSense prototype implements a number of demonstrative applications:

- ▶ The map application lets you navigate a map displayed on a nearby surface using hand gestures.
- ▶ The drawing application lets you draw on any surface by tracking the fingertip movements of the user's index fingers.
- ▶ SixthSense also lets you draw symbols in the air using the tip of your index finger and recognizes those symbols as interaction instructions. Drawing a magnifying glass symbol takes you to the map application or drawing an '@' symbol lets you check mail; Draw a circle on your wrist and SixthSense projects an analog watch on it.
- ▶ SixthSense recognizes your complex hand gestures. The SixthSense system takes photos of the scene you are looking at by detecting the 'framing' gesture. You can stop by any surface or wall and flick through the photos you've taken.
- ▶ The SixthSense system also augments physical objects in your vicinity by overlaying more information on them and making them interactive. For example, a newspaper can show live video news or dynamic information provided on a regular piece of paper. Touch any object and learn so much more about it than appears to the eye.

For more details on SixthSense log on to: <http://dgit.in/Xn9EZw>.

Steven Spielberg's 2002 movie *Minority Report* envisaged life in 2054, and shows the exceptional full-fledged Augmented Reality at work. For sci-fi fans, the pertinent memory is that scene in the movie when Tom Cruise's character Chief John Anderton strolls through a mall while everything advertised itself by bombarding him with personalized marketing messages. A Guinness billboard calls him by his name and tells him he could use a drink; the Gap store has holograms of assistants who ask him if he's enjoying his previous purchase; an American Express advertising displays a giant 3D credit card embossed with his membership details and so on; you get the idea. This "advertising nirvana" is based upon the possible existence of retinal

scanners; also, computer monitors and displays are transformed into holograms. With the virtual retinal display technology, the image is scanned directly into the retina of human eye. The viewer sees what appears to be a conventional display floating in space. This fancy technology is far from being a figment of your imagination and is currently under development at the University of Washington's Human Interface Technology Laboratory.

Augmented reality is changing the way we see the world. Someday you'll be walking down the street with augmented-reality displays, which will eventually look much like a normal pair of glasses, informative graphics will appear overlaid on your field of view in real time with synced audio.



Pranav Mistry with SixthSense



SixthSense's Visual Dialpad



AR in Hollywood; a scene from Minority Report

These enhancements will be refreshed continually to reflect the movements of your head. This remarkable technology blurs the line between what's real and what's computer-generated by augmenting what we see, hear, feel and smell. In the AR wars, Google is a step ahead of everyone. Google's Project Glass is developing a wearable spectacles like device that would overlay information on the eye's view and could interact with the Internet via natural language voice commands. The device will have Google's Android operating system. The prototype has been worn by Sergey Brin, co-founder of Google, to several occasions. He demoed the glasses at the Google I/O



Sergey Brin with Google Glasses

presentation in June 2012 where skydivers, abseilers, and mountain bikers wore the glasses and live streamed their point of view to a Google+ Hangout, which was also shown live at the Google I/O.

Google Glasses have also been compared to Steve Mann's EyeTap. An EyeTap is also a type of wearable computing gear for one eye invented by Steve Mann in 1980s. The design allows the user's eye to operate as both a monitor and a camera. The first prototype consisted of a computer in a backpack wired up to a camera and its viewfinder which in turn was jerry-rigged to a helmet. With time, the technology evolved and the size of the device shrunk. The current version consists of an eyepiece that mediates the reality, a keypad with which the user can interface with the EyeTap and a small processor which can be attached to almost anything, even a WiFi device for pulling up data from the Internet. Delving into the technology behind this amazing gear, we find that an EyeTap uses something called a "beam splitter" to send the same image to both the eye and a camera. The camera then digitizes that reflected image and sends it to a computer, which processes it. The result of all this processing is data that is sent to a projector that will then be overlayed over the scene that you are viewing



Steve Mann with EyeTap

Interactive eyemaker Vuzix will also reveal their competitor to Google Glasses- Smart Glass M100, in CES 2013. The Vuzix eyepatch will have Android IceCream Sandwich and a 720p camera along with Wi-Fi, Bluetooth and head-tracking sensors. You can take stills, capture video (with playback and picture viewing options), answer the phone with a visual address book, read emails and texts and run various AR applications. This "modernized monocle" is supposedly iOS and Android compatible. Vuzix, which spe-

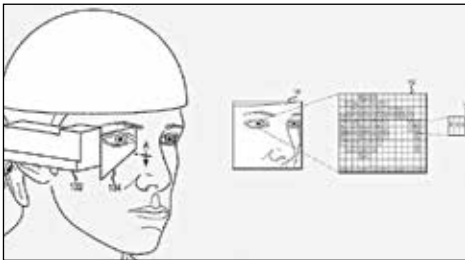
cializes in technofancy optics, created the first video eyewear to support stereoscopic 3D for the PlayStation 3 and Xbox 360. It also created other Augmented Reality eyewear, including the Wrap 920AR, Raptyr and STAR 1200.

Not lagging behind in the race, Microsoft has also patented Augmented Reality glasses for “live events”.

Here, “live event” is a broad term encompassing sports, singing and other things that are happening around you, including action replays and lyrics. Microsoft has recently demonstrated live language translation to and from Chinese. These AR glasses would enhance the stream of video by overlaying informative graphics. The device is expected to cover a wide market with its “live event” idea. According to Patently Apple, Apple too has got patents for its own retinized version of Google Glasses, granted in February 2010, which would work with a “handheld communication



Vuzix Smart Glasses M100



Apple's Sketch for AR glasses

device”. Although the sketch in the patent is not very impressive, it's an established fact that Apple never disappoints with its design.

With glasses and head-mounted displays in the making, companies are also focussing on developing AR con-

tact lenses. These lenses have embedded in them integrated circuits, LEDs and antenna for wireless communication. They let the wearer focus on two fields of view, the close-to-the-eye AR images and distant real world objects at the same time. Innovega, the company that makes them is trying to emulate display screens akin to what Arnold Schwarzenegger's character saw in the movie Terminator. These lenses, called iOptik are very much in demand by the US military. Now we might have agents like Ethan Hunt

from Mission Impossible 4: Ghost Protocol, wearing these AR lenses and pulling up information about everyone in sight. News on the block is that even Microsoft is trying to build AR lenses with help from the University of Kansas.

Apart from the wearable computing devices that use Augmented Reality, the technology is being exploited in many other areas. One of the great examples is the AR

sandbox, created by researchers at UC Davis University of California, which overlays a virtual, colored topographic map on a sand surface in real-time. As you change the topography of sand, make riverbeds and mountains, the 3D visual image adheres to the changes in terrain configuration. You can actually see the water flowing in the channel and fill up the basin. The image is overlaid by a Kinect 3D camera which is connected to a projector that overlays virtual information on the sandbox. The system is powered by an Intel Core i7 CPU and a Geforce 580 graphics processing



iOptik Contact Lenses



AR Sandbox

unit. Such AR systems can be used for educational purposes, for example for projects in science exhibitions.

Another cool device based on this remarkable technology is the Augmented Reality glove for your iPad. Ironically, now you can operate your iPad, a touchscreen device, without touching it. With this AR glove called T(ether) you can create virtual environments on the tablet. It lets you control iPad objects-pick them up, drop them down, push them aside or even create a new object by tracing the shape's outline- with simple hand gestures. T(ether) can be used by a number of people to collaboratively work on the same virtual environment for the editing and animation of 3D virtual objects. By using Vicon motion capture cameras, the position and orientation



T(ether) AR glove for iPad

of the tables, user's heads and hands, are tracked and spatially annotated in real-time. Watch the video on the following link to see how it works (<http://digit.in/Uo6x2P>).

With man still trying to perfect the above mentioned AR

devices, Augmented Reality has managed to find a foothold in the world of apps for your smartphones and tablets. It will be a while before you own a pair of AR glasses or an HMD like the SixthSense, but you can taste this sweet fruit via your smartphones and tablets. iPhones and Android devices have a vast market of AR apps for almost every aspect of human indulgence, from finding restaurants to recognizing landmarks and looking up satellites in the sky. More information on various popular AR apps is given in chapter 10 of this booklet. These AR apps use your device's GPS for looking up geotagged information, use your camera to receive relevant information of the world around you, and so much more.

And now AR is even making its way into cars. It builds on the "heads up display" (HUD) which is a transparent display that presents data to the user without him having to look away from the road. This technology was developed for military aviation for the convenience of fighter pilots

and began to make its way into high-end cars. These HUDs can be used to project directions or speed and other relevant information onto the windscreen in the driver's line of sight so the driver need not take his eyes off the road. While all this sounds very fascinating, augmented reality could allow these displays to get even better. Various car manufacturing companies such as BMW, Toyota, Mercedes and GM have shown off their prototypes of looking glass integrated with AR technology. The Mercedes Dice prototype conjures up information about passing places of interest and shows icons of friends driving past the car on the windshield with their social network status. Toyota has shown off their version of “enhanced car windows” that will allow users to zoom in on places of interest that they pass by. The enhanced vision system developed by General Motors goes one step ahead and uses an array of sensors and cameras mounted inside and outside the vehicle to monitor the on-road conditions. Apart from acting as a navigation guide, it helps you drive in foggy conditions and generate warnings about possible dangers. The display adjusts according to the driver's head movements.

Every one of us have different expectations from this technology. The near future can be seen but in the long term, this technology might always surprise you. One interesting perspective is that of the InteraXon Co-Founder Ariel Gartern. The company is working on a brain-sensing headband that receives your brainwaves

to monitor concentration levels, reduce anxiety, improve your memory and much more. They look forward to a future where brainwaves and AR work in tandem. The head mounted displays and AR glasses provide the opportunity to collect brainwave



Mercedes Dice

signals while the user continuously wears the device. This collaboration allows the computer system to present contextually aware overlays by noting your likes and needs. The system could continuously register and process your level of distress throughout your workday and present information accordingly. These systems would be “context aware” and would not only show relevant information but also present it in the way you want. For

example if it senses that you're sleepy, it would show you the hotels in the vicinity to spend the night. The real-time neuro feedback will let it know your brain state and try to optimize your experience. This is just one futuristic view; there is so much more to come. The bright side is that developers already have a far-sighted view and plans to exploit this technology and research is being done to make it a reality. 🇮🇳



DIFFERENT TYPES OF AUGMENTED REALITY

Augmented reality does not end at your smartphone. There are many more ways to enhance your perception of the world

Smartphones are probably one of the first objects where us mortals got to experience augmented reality; after all they are omnipresent. However, with time, as we look around us and observe closely, we find that augmented reality is prevalent elsewhere too.

Let us have a look at the types of AR. Before we begin, understand that lines are blurred, broken and twisted. Definitions explained here are not written in stone.

Projection based AR

Just like anything else which is beyond our reach, projection based AR feels more attractive (at least as of now) compared to an AR app you can install on your phone. As is obvious by its name, projection based AR functions using projection onto objects. What makes it interesting is the wide array

of possibilities.



Projection-based AR can build you a castle in air, or a dialer on hand

One of the simplest is projection of light on a surface. Speaking of lights, surfaces and AR, did you ever think those lines on your fingers (which divide each finger into three parts) can create 12 buttons? Have a look at the image and you would quickly grasp what we're talking about. The picture depicts one of the simplest uses of projection based

AR where light is fired onto a surface and the interaction is done by touching the projected surface with hand. The detection of where the user has touched the surface is done by differentiating between an expected (or known) projection image and the projection altered by interference of user's hand.

One of the widespread uses of projection based AR techniques is non-interactive. Projection on objects can be used to create deception about the position, orientation and depth of an object. In such a case an object is taken into consideration and its structure is studied in depth. The object's distance from the projection is calculated and the projection light sequence is then designed carefully to deceive the viewer's mind.

The most exciting implementation of projection-based AR is perhaps the most exciting one of all uses. We are sure it can appeal to your inner scientist

and even the child inside you. Pop over to your PC or Smartphone and watch this video:<http://dgit.in/U954At>. It shows Laser Plasma technology in action creating 3D images in air. That's right - 3D images in thin air. This is one of those technologies which can not only be used for AR, but for a whole lot more. Not only can this piece of tech be used for creating virtual object in the air itself, its future developments may make it useful enough for much larger deployments. In some cases, it might eliminate the use of special gear (such as goggles and head mounted displays) for experiencing AR.

Recognition based AR

Recognition based AR focuses on recognition of objects and then provide us more information about the object. e.g. when using your mobile phone to scan a barcode or QR code, you actually use object recognition technology. Fact is, except location based AR systems, all other types do use some type of recognition system to detect the type of object over which augmentation has to be done.

Recognition based AR technology has varied uses as well. One of them is to detect the object in front of the camera and provide information about the object on screen. This is something similar to the AR apps for travellers (location browsers). However, the difference lies in the fact that the AR location browsers usually do not know about the objects that they see while recognition based AR apps do.

A second type of recognition-based AR application is to recognize the object and replace it with something else. The applications, once again are in abundance and possibilities endless. Some examples are given below:

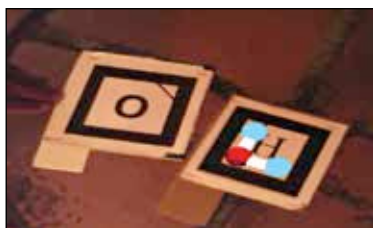
- 1 Simulation of objects in 3D. In this case, printed version of a recognizable object (such as a card with QR code printed on it, or a picture provided by the app printed on paper) is shown to the camera. This printed version is called "Augmented Reality Marker" and acts as a reference for the AR app running on the system. The augmentation app detects and recognizes the marker and tries to understand the distance and orientation of



Recognition based AR at work

the print. Once the recognition is complete, it replaces the marker on screen with a 3D version of the corresponding object. This allows the user to investigate the object in more detail and from various angles. Rotating the marker would rotate the 3D imagery as well.

- 2 Yet another famous use of recognition AR tech is - translation of words on the fly. In this case, the app reads the words seen by the camera and tries to recognize the words using OCR (Optical Character Recognition) technology and then replaces the words on screen with their translated versions. This can be immensely useful for tourists when travelling to places where the locally prevalent language is not known.
- 3 Recognition based AR can also be used in education. Markers of more than two objects are kept together. The app detects the multiple markers and tries to simulate relationships among them. For example, one can use printed cards to represent atoms (in say chemistry class) and based on their mutual distance the AR app can show how a reaction would take place; and that would be just one use of AR in education. Detection of drawings and sketches by more intelligent apps can help teach small children. e.g. a picture of a giraffe be replaced with a living 3D version of a giraffe and children could see how it looks in reality and they could interact with the same on a touchscreen!



Augemented Reality for simulating chemical formulae

- 4 Recognition of printed versions of 3D objects can help create 3D simulations of those objects without having to actually build a physical model. This can be of great aid to people who constantly work with 3D applications such as architects and animators. We will talk about them in later chapters.
- 5 Recognition based AR can be used in projectors to automatically detect a projectable surface and project on only the projectable area. The projection can be made interactive by using dynamic objects in the surroundings to command the projector. This can eventually be used with the projection mapping technique to auto-detect various types of objects and send out projection imagery according to the size, distance and color of the surface on which projection could be done.

With projection based AR, your imagination is the only limit. There is a lot of research going on in this field and with time, more and more applications would pour in. If you are really excited about how you can create something like that of your own, we have tips for you at the end of this book. For now, let us see the location based AR.

Location based AR

It would be an injustice not to mention this category when talking about AR. Location based augmented reality is one of most widely implemented applications of AR. The strongest force behind this is the easy availability of smartphones and the features that they provide in terms of location detection. Location based AR is mostly used to help travellers in their journey.

Location based AR in most cases is used for AR location browsers which help users discover interesting places within their current location. This method works by detecting the user's location and orientation by reading data from the mobile's GPS, digital compass and accelerometer and predicting where the user is looking; then adding related information on screen about the objects that can be seen from the camera. Wikitude is one such application. If you've never used the app fear not, this video would help you realize how it looks in action: <http://dgit.in/WkXxwS> There are other interesting uses of location based AR which we will talk about in the coming chapters.

Outlining AR

Though the human eye is known to be the best camera in the world, there are limitations. We cannot look at things for too long. We cannot see well in low light conditions and sure as anything, your eye cannot see in infrared. For such cases, special cameras were built. Augmented reality apps which perform outlining use such cameras. Once again, object recognition sits behind all that outlining AR can do. Let us begin with a life-saving implementation example.

- 1 When driving a car on a road in foggy weather, the boundaries of the road may not be very visible to the human eye, leading to mishaps. Advanced cameras tuned specially to see the surroundings in low light conditions can be used to outline the road boundaries within which the car should stay. Such a system would prove very useful in avoiding accidents. With extra sensors capable of detecting objects around (e.g. by using ultrasound) the overall risk of hitting some living object can

be minimized as well. The technology can help you save pedestrian lives as well. Outlining people crossing the road on a HUD (Heads Up Display) windscreen can be more useful than having a separate infrared video feed.



Outlining the road can help save you a mishap

- 2 An AR app known as 110 stories allows you to see the twin towers of world trade center in New York as an outline. This might a tad morbid but it certainly is interesting. Outlining monuments from history can be utilized for many purposes the foremost is of course education.



Outlining the buildings from yesteryears is a creative use of outlining based AR

- 3 Outlining AR can be used by engineers and architects to look at a building and study the location of supporting pillars and metal bars. Such an application could fetch the building's construction data from a database and provide a mesh/framework view of a building and can prove to be an aid in repairing a building or be used for educational purposes.

Superimposition based AR

Superimposition based AR provides an 'alternate' view of the object in concern, either by replacing the entire view with an augmented view of the object or by replacing a portion of the object view with an augmented view. In this case, once again, object recognition plays a vital role - logically, if the application does not know what it is looking at, it most certainly cannot replace the original view with an augmented one.

Depending on what type of view is required, the technology can be used for multiple purposes.

- 1 Doctors can use the technology to examine the patient from various angles in real-time. A live feed from an X-Ray machine can be used to superimpose the X-Ray view of the patient's body part on the real image

to provide better understanding of the damage to bones. The application can be made to work via a head mounted display or special goggles. In other uses, the view can be shown on a screen where the video feed is taken from a real camera and X-Ray vision can be imposed on it.

- 2 In military applications, superimposition based AR can provide multiple views of a target object without showing extra information in text and blocking the vision of soldier from other important objects around. If you have been shooting enemies via your computer mouse, you'd already know how it would appear. Superimposition of infrared view or radioactive view of an object or an area can help save lives; or win wars!
- 3 Superimposition of ancient pictures over real ones can provide interesting views of historical places. Broken monuments can come back to life in all their original glory. Perhaps different eras complete with landscapes can be re-lived with AR.
- 4 To allow a tiger or snake near you might be a horrifying experience with hazardous consequences, except when superimposition AR is used to bring them to you. Placing a person in a location or situation which is otherwise dangerous can be safely accomplished via superimposition AR!
- 5 Superimposing a real object with its internal view can be helpful in education as well, for instance, to study bone structure.

Though we have touched some of the most important types of augmented reality, there are a few others which cannot be easily classified to fall in one of the above said ones. These types use more multiple sensors and may produce the result in different forms. Such systems employ special faculties of dedicated devices working in parallel with processing systems with algorithms developed especially for being used in AR. As more input and output devices converge to more powerful and efficient systems, we would come across more types of AR in future. 



Superimposition AR can be used for educational purposes as well



AR: THE LIMITLESS POSSIBILITIES

Augmented reality is not just about fun and games. There are some substantially beneficial uses for the technology in everything from engineering and medicine to sports, education and more

Technology usually evolves through two pathways – someone “builds” a new technology out of necessity to solve a particular problem, or someone “discovers” an existing technology and finds ways in which it can be used to solve new problems (which the original technology may not have been designed for). Augmented Reality (AR) is one field that owes its evolution to both aspects equally. As new information demands emerged, new ways of adding information to reality were found. Each passing day sees an increasing number of applications of augmented reality, and its potential seems endless. In this chapter, we show you how AR is already modifying our lives in some key areas, and what to expect in the coming years.

Military

Although, the prime motivator behind all innovations in military technology is to make it easier to defeat the enemy and prevent the reverse, several technological breakthroughs do find their way into civilian hands. AR is one such advancement that has significantly increased the success rate for other systems and even military.

Wait a minute! Chances are that you are wondering when was the last time you used AR, and that too as a military application. First person shooter (FPS) games, of course. Most FPS games show some really innovative use of AR: name of buildings, teammates and weapons as you hover the mouse pointer over them, and indicating directions to the next checkpoint without ever having to shift your focus from the screen center.



AR can be very useful in military

However the future promises a lot more. Aided with superior tactical gear carried by military personnel during an operation, AR can even reveal things that are hidden to the naked eye – enemy movements behind physical objects, type and range of enemy weapons, points of vulnerability in the enemy's defences, simultaneous tracking of multiple enemy personnel – all of which soon prove indispensable to infantry of tomorrow.

Picture is a screenshot from a game. Please crop the more interesting area if needed. Can be used as-is though (text provides grounds for relevance)

Vehicle Windscreens

Gaming is so much of an inspiration for AR that this application has also materialized out of popular games. Being a smart Digit reader, you would have already guessed what genre of games we are talking about: racing.

When you race cars, bikes, trucks, kayaks (basically, anything under the sun) in a game, a lot of information is usually displayed on screen. This may include speed (displayed either on a digital or an analog speedometer), distance from a vehicle, milestone, or random objects in front of you, a map of the path that you are following and visual indications of a sharp turn ahead. Depending on the game, your virtual windscreen may also tell you where cops are waiting for you and whether or not they are following you in a chase. While several developers are working on it, the technology still has to see the light of the day in the real world. One simple application of would be to send a visual alarm as soon as you near or exceed the speed limit.

The innovation and possibilities do not end here. If AR is blended with MANETs (Mobile Ad-Hoc NETWORKs), it can be used to provide drivers with information slow-moving traffic or nearby accidents. On detecting low fuel levels in your gas tank, in addition to alerting you, AR may also visually guide you to the nearest fuel station. Through visual notifications and icons displayed directly on-screen, AR will guide you to your desired destination in a new city, without needing you to calculate the 'next turn according to map' by looking down at an LCD screen.

We are not going to put any pictures but links to two videos:

1. GM testing AR with one of their cars: <http://www.youtube.com/watch?v=94dg2D-jAbM>
2. BMW's HUD: <http://www.youtube.com/watch?v=b4jpuoGP2C8&feature=endscreen>

HUDs

HUDs (Heads Up Displays) are spectacles, windscreens, or other surfaces



AR in Heads up display

which allow the viewer to see through them but add extra information over (or around) some specific objects. They allow the viewer to get more information about things that he is looking at, without having to shift his focus to a secondary panel. Fighter jets are among the most loyal consumers of HUDs, as popularized in various movies, such as Top Gun way back in 1986!

HUDs are one of the most important implementations of AR. Fighter planes are built to be used in close-combat situations, where a even the slightest mistake can cause heavy losses. Hence it becomes extremely important that the human operator flying the plane has access to as much information as he can about the things he is seeing without having to shift his eyes from the scene up ahead.

HUDs are being brought into the hands of the common public via spectacles (it's gonna take some time though). Remember Google's Project Glass?

Please keep the picture as large as possible to show the details

Medical Sciences

The fact that AR can provide more information and with minimum distraction makes it a prime candidate for the medical sciences. There are already apps such as Mole Detective that determine the likelihood of skin cancer

by analyzing an image taken using your mobile phone's camera! Of course we wouldn't vouch for their efficacy at this stage.

AR has considerable potential in saving both doctors' and patients' time. AR when combined with current advanced medical equipment can help vis-



AR in XRay

ualize and graphically display the medical issue with the patient. Special goggles can superimpose an x-ray image, previously captured by an x-ray machine, with the real-world view of the patient lying on the operation table.

AR is also used in MIS (Minimally Invasive Surgery) where a small camera is inserted into the patient's

body. One use-case involves using AR to help visualize the brain inside a patient's head. Another involves highlighting the location and extent of hairline fractures in a patient's bones, and recommending ideal next steps an orthopedic surgeon. Other uses include visualization of anatomical joints in live motion, tracking small surgery tools during an operation and simulating the birth of a baby to check for any possible complications.

Shopping

Sales are what makes our world go round, and hence developers always seek to connect technology to sales. AR may prove to have immense impact on retail sales.

Although the internet has revolutionized shopping to this day, we still tend to visit brick-and-mortar outlets on a regular basis. One of the major reasons people capable of buying goods on the internet go to physical outlets is to 'see, touch and feel' the product before they buy them. Malls can leverage the capability of AR to its best by allowing consumers to choose the best product for themselves via 'virtual trial rooms'. which allow shoppers to look at themselves in particular outfit or an accessory without having to actually wear it.

The technology works by using a camera (or multiple cameras) to capture an image of the shopper, and superimposing the clothing item or accessory



AR in virtual trial room

of the ideal size over the shopper's body (instead of that of the model used in the advertisement). A look at the numbers and you would be able to imagine how much profitable AR can prove to retail businesses. Imagine, a company that developed a similar product says that the business is worth \$600 million if implemented by today's brick-and-mortar shopping industry. Augmented reality can equally benefit web-based retailers. Do watch this video to see how AR has already made an entry into the retail sphere: http://www.youtube.com/watch?v=NxQZuo6pFUw&feature=player_embedded

NOTE

The picture is a snapshot taken from the video mentioned above. Can be removed if needed

Tourism

Tourism is another industry that may can utilize AR to its advantage. Even according to Wikipedia, "Augmented reality (AR) is a live, direct or indirect, view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data." Including 'GPS' with sound and video in AR makes it really valuable for travel and tourism business. Let us first take a small step back to try and understand the 'why' behind the AR-Tourism relationship.

Travel is both a luxury and a necessity of modern life. No matter what the reason be, when travelling, we are always looking at things or looking for something. For example, if you are travelling in Kolkata and you pass

by Victoria Memorial not knowing what that building is and its place in history, you would probably say “ah, that looks like a nice colonial palace” and stop at that. However, while travelling, we are continually looking out for information, let us say the nearest restaurant in a city unknown to you. An AR browser application (which helps you browse your locality with AR information) could visually guide you to your point of interest.

From yet another perspective, travel has for long been associated with carrying paper maps, books to read during a journey, and paper to take notes on. The mighty mobile phone has replaced most of these items. Further, the development of smartphones has reduced (if not eliminated) the need to carry multiple ‘information sources’. A single device can now encompass a GPS, camera, accelerometer, internet connectivity and a compass in our mobile phones.

AR browsers can guide you step-by-step from point A to point B without ever needing to look at a map. However most AR applications currently do not ‘understand’ what is in front of you. For instance, current AR applications do not transmit the live video feed sourced through a mobile camera to some remote server to tell you what you are looking at (such an approach would be very expensive from the computational viewpoint and also consume a lot of bandwidth). Instead, information about where you are standing and what direction your camera is facing, in the form of GPS, compass and gyro-sensor data, is sent to the backend server of the app.

However, these technologies still require several improvements in accuracy and usability. Since the application does not understand what you are seeing and depends on GPS, gyro-sensor and compass data, the unavailability of any of these services will degrade the experience of the app by a large degree. For example, if the compass in your phone accurately calibrated by 90 degrees (i.e., east becomes north and north becomes west), then depending on AR app would require you to hold the phone in front of you and walk to your left! If the gyro-sensor fails, then the app might just tell you to dig the ground to reach your destination. However, such a case would be rare. What is more common is losing the GPS signal which would make the AR browser totally useless.

Even with GPS, the information being displayed can be slightly wrong. GPS detects your position with an approximate error of anything between 10 to 20 meters. Such an error can show you wrong information when you are at crossroad where multiple roads intersect or in a historical place where



AR can be fun as well as useful when travelling

you are jam packed with points of significance. Also, in most cases, people tend to ignore the AR applications and instead rely on mapping services such as Google maps to get what they want. Again, it is quite a difficult task to keep holding your mobile phone in front of you at all times to learn about the place you are in.

That was all about how AR can be implemented in the tourism industry. It's time we find out what is already out there.

Multiple applications with AR capabilities exist today, most of which work by combining GPS, compass and gyro-sensor information to figure out where you stand and what you are looking at. However, these applications are still incomplete in terms of data. A major portion of the world still needs to be mapped and it is going to take significant amount of time, effort, money and computational resources to store and deliver that information. One of the most famous AR applications available for iPhone and Android is Layar (pronounced 'layer') where users can create their own layers filled with information of places they like and the appropriate layer can then be loaded on the application to assist you using the AR techniques built into the app. The by the application creates the augmented reality by deriving information from the layer's data.



AR can be used to relive the past!

Individual users creating layers of information for small places with a layer-based approach makes it a lot more easier and helpful, than for a single organization to try and map out the whole world. For example, one may create a layer containing information of a museum's exhibits, and allow visitors to access this information by simply pointing the camera at an object of their interest. It might also be used to 're-live the past'. For example, if you see a sword in a museum, then AR could make it even more interesting by showing it in action --- such as presenting the image of a past emperor to whom it belonged actually holding the sword!

Another important use of AR for historical places can be in form of historical image superimposition. For example, you visit New York and point your camera to Statue of Liberty; an AR app then lets you choose images of the Statue and its surroundings at different points in time, and then superimposes them on the live image.

Architecture

If you have seen either of the movies 'Prometheus' or 'Avatar', then you already have a hint of how AR can help in architecture. AR can help visualize structures before they are actually built and simulate their behavior under various weather conditions. Not only this, it can also help convert 2D prints into 3D visualizations and project time in space in front of you, thus providing a much

better understanding of the building than what a normal print can convey.

Yet another way of using AR in architecture is to utilize superimposition techniques to visualize how an architectural change would look in reality. Utilizing AR in an architect's workspace can help the architect visualize his design as if it were live. Special goggles with little help from 3D processing units can convert the workspace into a super-advanced arena of imagination where 3D drawings made in CAD software on computers come alive much the same way as Ironman designs his toys.

NOTE

I would like all the three pictures be printed as they together speak more than what can be said via words



AR in architecture can provide a high grade of imagination and aid to the architect

Sports and Entertainment

All work and no play makes AR look like a dull technology which it is not. AR can be as much fun as it is useful. You have already seen AR at work at several recent sports events, though this might not be obvious at first glance. A prime example is displaying the score and names of players directly on the field of play. AR also provides invaluable help in analyzing crucial event in real time, which in some sports can totally change the outcome of the game. Does not sounds familiar? Let us augment your knowledge with familiarity then; let's talk about cricket.

The LBW (Leg Before Wicket) is a well known method of dismissing a batsman, depending on (i) the trajectory of the ball and (ii) the object that the ball touches first in its trajectory. Instant action replays incorporating the AR technology called "Hawkeye" plot the trajectory of ball and predict whether the ball would have hit hit the stumps if it followed on its path



AR can have huge impacts on results of a game!

without deviation. Another AR system known as “Hotspot” uses infrared cameras to highlight the point of contact between the ball and other surfaces based on show small deviations in temperature due to friction.

Besides cricket, AR is also used in other sports such as in swimming to compare the current position of the lead swimmer with those just behind him or with a projection of where the world holder would be if he were in the same race. The sport of tennis has adapted AR technologies brilliantly to assist umpires and viewers in line calls, and football seems to be following closely with proposals by FIFA to introduce goal-line technologies.

Advertisers are also utilizing AR to display ads in strategic positions on the field and having them blend with real-world elements.

AR techniques are also being widely used in amusement park rides and stalls where children can play with virtual animals ranging from small puppies to giant dinosaurs. About a year ago, National Geographic along with app-shaker demonstrated the possibility of AR in a shopping mall in the UK where people were amazed to see their own images but with wild animals and astronauts.



AR can be very entertaining

This video should give you a hint of the same: <http://www.youtube.com/watch?v=TL62txWNFMU> and we recommend you better be prepared to be awed.

Education

AR sure has a huge role to play in the future of education. Instead of teaching ‘A for Apple and B for Ball’ to little children with picture books, AR can be used to visually project real-looking apples and balls in front of them, and also have them experience these objects via other senses (touch, smell, sound and taste). Teachers could use applications which can simulate chemical reactions, physics phenomena and maths concepts. They may “liven up” biology classes by creating virtual operation tables. AR could considerably reduce teacher. For example, a simulation of how various atoms and molecules would interact when brought close to each other would allow students to experiment and learn the concepts on their own. Rules could be understood faster and more easily even when a teacher is not present.

Below is a list of a few interesting videos here to show how AR is going to revolutionize the way kids receive education in the future:

- ▶ Chemistry lab simulation: <http://www.youtube.com/watch?v=d8KXOrFLMoc>
- ▶ Yet another chemistry lab simulation: <http://www.youtube.com/watch?v=cPYKMbR5OoO>
- ▶ Mathematics: <http://www.youtube.com/watch?v=jKn7W8uAt3k>
- ▶ Biology: <http://www.youtube.com/watch?v=6N8-x5WTjba>

Art

There is no better word to exemplify the uses of AR technologies in the field of art, than “Photoshop”. Adobe Photoshop, with the plethora of options and effects, is that special software that deserves recognition in IT heaven for turning many a nerd into capable artists. By superimposing images on top of each other, Photoshop allows new images and effects to be created. Detecting patterns and predicting their continuity in a scene can help turn boring things around us into pieces of art. Combined with dedicated and powerful hardware, AR could transform the sunset from your balcony into the most beautiful sunset on a beach! Mobile apps now let us “touch up” photos soon as we click them. The popular ‘negative’ and ‘sepia’ effects also qualify as means in which we have augmented our realities and produced pieces of art.

Machine-assisted translation

AR's role in tourism does not end with maps, directions and points of interests. Wondering how else would a machine help you see a world differently when you are travelling? By assisting in translation, of course. Languages serve both as bonds and as boundaries when it comes to communication. When you travel far enough, bonds may easily turn into boundaries. For example, being able to understand your surroundings well, while you are in Spain would require you to understand Spanish. Billboards as well as restaurant menus may become intimidating in no time. Well, you do have a translation app or dictionary on your phone, but are you ready to translate all that you encounter into your preferred language? Well, good luck on your path to frustration and killing the joys of travelling.

AR can provide immense help while you travel by translating any content that you encounter on the fly. There is no need to keep tapping in words to understand what a restaurant offers on its menu. All you need to do is to point your mobile phone's camera at the menu and look at the display and you would be reading the menu in your preferred language in no time. This is achieved through several apps available in app stores, which almost instantly translate content captured through mobile phone cameras. Some of the really clever apps have been able to completely blur the distinguishing points the augmented and real-world features.

One such application for iPhone is 'Word Lens' and we recommend you to watch it in action: <http://www.youtube.com/watch?v=b2OfQdYrHRs>. We are sure you would love the innovative uses it can have. 

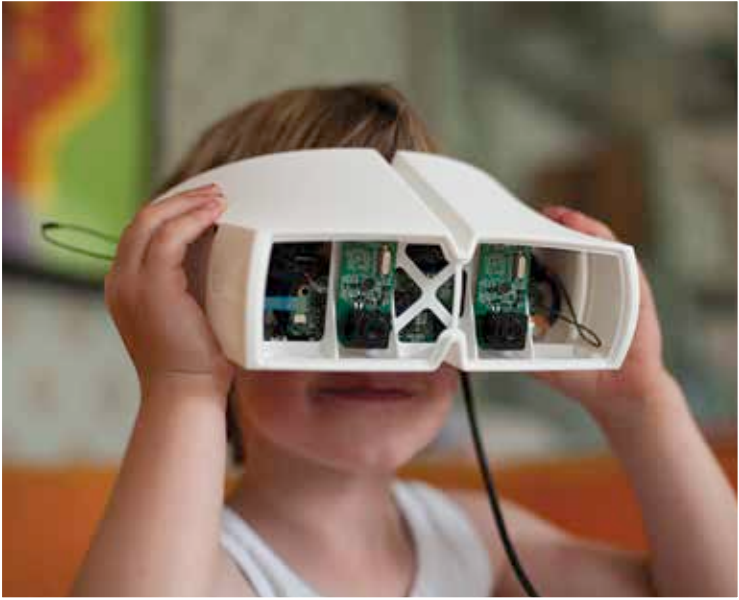


Image credit: arlab.nl

HARDWARE FOR ILLUSION - WHAT MAKES AR TICK?

Hardware and sensors are very critical
in the implementation of Augmented
Reality. Find out how...

As you have probably figured out by now, Augmented Reality depends a great deal on the hardware. In fact you may even say it's vital to its existence. In this chapter we will introduce you to the tools of the trade, the machinery which together will shape the way we will perceive our world in the future.

The basic kit

Although augmented reality has a lot of uses in various fields, they all have few similarities that cannot be ignored. They all need some sort of input which needs to be augmented. This input is fetched from the camera, most of the times. Next comes the part about deciding what graphical information needs to be shown on screen; depending on the application, the magnitude of annotations vary. However, in all cases some sensing devices are required to fetch information about what needs to be displayed. Depending on the type of interaction that the AR application needs to do with the user, it may need other input devices (for e.g. a tourism AR browser might feature a touch-to-learn feature). Next comes the dough of AR: a processor which combines the visual data being fed into the system with the processed changes that need to be displayed. Since we are in need of displaying the augmentation, AR also needs a display in most cases.

One size does not fit all

Depending on what the application is, in addition to the common hardware we mentioned above, it might need some more. For instance, the use of AR in tourism would need inputs from a GPS unit, an accelerometer and even a digital compass. On the other hand, usage of AR in military might require additional tagging and real world path highlighting. It might need information from custom devices, the local map and a few other information sources to assist the soldier. A virtual shopping trial room would work well enough with a webcam. In this chapter we take a look at the Hardware involved in AR, starting with display.

Displays

There are numerous ways to show the augmentation in AR systems and it is affected by the usage scope of the particular AR application. As per use-case the screen will differ. Let's find out how.

Head-mounted display (HMD)

Head-mounted displays are the type of displays which can be mounted

(worn) on the head of a person. At times they are also called as ‘helmet mounted displays’. HMDs are of two types out of which one cannot be used for AR.

1 **HMDs that display only CGI** - Most HMDs that you can find in the common market (though you will not be able to find them easily) are of this type and display only computer generated images (CGI). These HMDs are the ones which cannot be used for AR. The main requirement of AR is to augment the reality. Since these HMDs do not feature a real-world view capability in the first place, the question of augmenting the view gets out of scope. These HMDs are usually used in virtual reality setups.

2 **HMDs that allow superimposition of CGI with real world view** - These displays are capable of displaying real world imagery on which superimposition of additional data can be done. These once again are of two types:

a **Video see through:** These HMDs take in the real view via a camera and mix the CGI information onto it.

b **Optical see through:**

These HMDs allow the real world to be viewed through a semi-reflective mirror and project the CGI data on to the mirror using a projector device. The mirror being half reflective only, creates the superimposition effects. Yet another type of optical see through HMDs are the ones which use OLED displays which act as both viewing glass as well as displays.



One of the various types of HMDs

HMDs are one of the most useful type of displays although they are not the most common ones. The usage of HMDs are many.

- 1 **Military:** HMDs displays are built into fighter jet pilot's helmet to displays important information about the flight and target. Often they have useful features like night vision and the visors may even be protective. HMDs are also used for the army and police where the displays show vital information about the surroundings e.g. maps and thermal imaging data which can help detect a targets in very low light conditions. These HMDs also feature communication gear for coordination among soldiers as well as for receiving commands from base. Most military applications of HMD include a OLED display instead of a semi-reflective mirror.
- 2 **Sports:** Sports such as formula one racing can use AR with HMDs to show some important data about the race to the driver.

HMDs feature head movement detection thus providing an intuitive and immersive experience to the user by giving them six degrees of freedom

NOTE

Degrees of freedom is a concept of mechanical engineering which determines what type of motions are allowed for an object. The degrees are divided into two sets:

- 1 **Translational:** Movement of the object from one point to another. The three degrees under this consist of movements along the three axes of cartesian coordinates in space.
- 2 **Rotational:** Rotation of object in the directions pointed by the axes in the cartesian coordinate system.

Eye Glasses

Eye glasses that are used in AR are essentially stripped down versions of HMDs. They do not feature all the tactical advantage of HMDs and the augmentation is simpler. In most of the cases, eye glasses used for AR purposes look just like the normal glasses with an additional camera. These devices allow the user to see the world as they would wearing the normal glasses

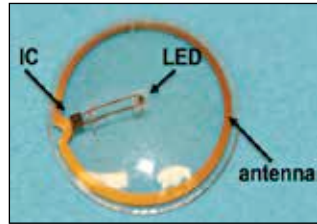


AR eye glasses look like the normal ones, though with a camera

and add the augmentation onto the view. They feature OLED displays which allow the extra layer to be displayed directly on the glass. Some of them use the semi-reflective mirror approach as well.

Contact Lenses

As strange as it might sound, contact lenses are already in development which would cover the eye with hundreds of LEDs to augment reality for you. These contact lenses are essentially tiny displays which can be controlled by the built-in circuitry. As technology progresses that tiny amount of real estate will even have integrated systems for



Contact lenses capable of doing AR are going to be available in the future

wireless communications. There is still research going on in this area and the technology is only a little way past the drawing board. One of the ongoing researches includes utilizing solar energy to power up all that electronics in the lens.

Handheld displays

If you are a smartphone user, chances are you have already used AR applications. Even if you are not, we believe this is one AR display which is not going to send any shockwaves of awe. Handheld displays are the most common AR displays and a lot of people already have them in the form of smartphones. These displays possess nothing special in the hardware department from the AR viewpoint.

It is the other hardware components of the phone which bring in the specialties. The components which aid AR on these displays mostly consist of a GPS module, accelerometer, digital compass and components used for data and communication.

The disadvantage of handheld displays is that one needs to keep holding the device in front of oneself all the time.

Spatial displays

Technically speaking, these displays are not the normal screens found in other devices. Instead, the display is done using a projector. The projector projects the augmented view directly on the object of which the augmented view is needed. That being said, these setups (we would call them 'setups' instead of 'displays' to save you some confusion) are not meant for individual users but for a group of users.

Spatial displays have the advantage that they need not be worn or carried around (well, literally you cannot as they are preset for a given environment

only) and since all users of the SAR (Spatial Augmented Reality) setup can see each other, they can easily collaborate.

Though we have mentioned quite a number of displays that are used for AR, there are others which are not as popular. Let us now go to devices and methods used for inputting data into the AR systems.

Input hardware for Interaction

“We think basically you watch television to turn your brain off, and you work on your computer when you want to turn your brain on.” - Steve Jobs

While opinions may vary greatly when it comes to Steve Jobs, it is pretty difficult to defy the logic contained in the sentence quoted above. Interaction is the main difference between two things that look just alike: a television and a PC. Both of them have got a display system but the former does not allow you to play as much with it as the latter does. While a TV would allow you to change channels and turn up or down the volume, a PC allows you to do much more (even while speaking of simply entertainment).

AR is one of the most active areas of research in computing but strangely AR doesn't require much interaction. In fact much of the interaction occurring within different types of AR implementations is automated to a level that you do not have to command the system once it has started working. A lot of research is directed towards minimizing whatever interaction you do with the system. For instance, if you were to wear a HMD, you would not want to keep pressing buttons to command the HMD to display what is on the right, instead you would turn right and the HMD would do the job of augmentation of the environment to your right. Such an experience does not require you to constantly command the system. The system detects your movements and based on prediction of what you would want, changes the view.

But not all AR implementations are used or are intended to be used without any interaction. Take for example the tourism AR applications you could install on your phone. Some of them do require you to tell them what information you want augmented into the real view. In the famous AR browser application 'Layar', you would have to first select the 'layer' of information which should provide the augmentation. Other methods of manual input involve verbal commands that can be given to an AR system.

Let us again take the example of HMD. In most cases a HMD would cover the entire viewing area in front of your eye. In such a case it becomes very cumbersome to command the system using controls such as buttons.

Hence advanced HMDs must feature a system which allows them to command the system using voice. But of course voice may not always work well in all AR systems. For example, if an architect is viewing a 2D drawing of a building in 3D using a HMD, commanding the HMD with voice to show minor changes in design will be a much more frustrating experience than using a wand or stylus to alter his view.

Another way to send commands to an AR system is in the form a glove which detects the subject's hand gestures and sends them to the processing unit which then takes an appropriate action based on that gesture. Yet another method to send manual input to an AR system would be touch. For example, an AR browser could be designed to show extra information about a building in front only if you touch the image on your mobile phone's display.

Input hardware for tracking changes in environment

Before going further, we want to clear the point that all interaction hardware are input hardware in their own right. They allow the user to input commands to the system. What we are going to talk about in this part is not about them. In this part we talk about the hardware which allow the AR implementations to function automatically (and intuitively). Let's start with the implementation of AR which we can encounter first hand - AR browser applications built for mobile phones.

Use of AR on your mobile phone to assist you during your journey is one of the simplest usage of AR systems. Most AR browsers use a lot of information sources built into your phone to add information to your view of places around you. We have said earlier that AR browsers as such do not understand what they see. They show the information from the server (for the app) which depends on your phone sending its location and orientation. To learn the location, the AR browsers use the GPS module built into your mobile phone. If you are not getting GPS information, then the server for the application cannot know your exact location and AR would either not work at all or if it works, it would be inaccurate. The second piece of information it needs to know is which direction you are facing which is supplied by the compass built into the phone. The third source needed is what angle you are (your phone is) looking at from the ground. For example if you are trekking and you point your phone towards the base camp then it is important for the AR application to know that you were looking down or else it might mark the base camp as the hill's peak. The information about the angle of

view is provided by the accelerometer in the device (the same thing which auto-rotates the pictures and videos as you turn your phone). Depending on the application, either the server or the phone calculates what the camera is seeing the then superimposes the information with the placemarks.

HMDs, one of the prominent devices used for AR can facilitate quite a number of functions depending on what these are built for.



Infrared inputs built into AR systems for cars can help prevent accidents

HMDs which can be used by armed forces usually contain all components an AR browser for mobile would i.e. GPS, accelerometer and compass. The compass and accelerometer in the HMD can be used to track head movements to provide a more immersive experience. Another addition can be that of eye tracking. If the computer has the sense of where the user is looking, it

can improve the interface by adding more details to certain types of objects in the direction where the user is looking or help focus the user on only that area by causing other portions of screen to fade. However, in some cases the HMD does not have to contain a GPS such as when it is to be used in a closed environment and the position of the HMD is already known to other components of the AR setup. An engineer's workspace could be an example.

Additional input can be provided to the HMD using hand movements which can be done using special gloves which can be connected to the HMD using either wires or short range wireless methods (e.g. bluetooth). This enables gesture based input to the HMD for commanding the HMD without the use of voice. Gesture based input is used often for entertainment purposes wherein the user is allowed to play with virtual objects while hand tracking enables the user to interact with virtual objects. The day may not be far when you would be wearing a complete AR suit that adjusts what you see based on your blood pressure, skin humidity, muscle activity and other factors.

Infrared sensors can be used to aid night vision as well as to see objects normally hidden from eyesight using clever use of colors. These can be used to show the presence of an object which might be perilous and save a life.

For example, use of infrared sensors in the windscreen of cars which can help drive safer in night by showing hot objects from a distance. This can include humans crossing the road.

Despite so many input devices already present for AR, there are a number of methods being devised further to make the augmentation so intuitive that it blurs the lines between reality and augmented reality.

Processing

It is this part which actually does the work in any computing systems. No matter what computing system you pick up for the case study, it is the processing that would be at the center of it all. If everything works but the processing system is not working well, everything else – all input devices, tracking hardware and display systems – becomes useless. When it comes to AR, processing is more substantial and critical than other parts. Obviously the processing units and methodologies are not simple at all. In fact they are sophisticated enough that this FastTrack is beyond the scope of any in-depth discussion on them. No matter, we will simplify the process for you in the next chapter and pique your curiosity a little more. 



THE MAGIC BEHIND THE SCIENCE

We have answered the when, who, what
and why of augmented reality. It's time
now to answer the how

The past few thousand words were dedicated to tell you about the hardware that's used in AR. Before that we have been talking about the needs, significance and history of AR. We even talked about the different ways in which AR is implemented. It would

have become obvious to you that the technology is not simple. At various levels, we are in need of different techniques to achieve the goal. In the following few pages, we talk about the technologies that bind together the various parts to produce the mesmerizing effects of AR. We would go through each type one after another.

Projection based AR

We start off with projection based AR because the number of technologies and complexities of their interrelationships are the minimum here. In case of projection based AR, one has to deal with only a few parameters. The primary point of concern, as we have already said, is the creation of image sequence which is to be projected. Depending on the needs, quite a number of tools can be used. Let us begin with non-interactive AR.

Non-interactive AR

If the projection surface is just a plane surface, it is easy to generate the video sequence. The software required for the same would depend, once again on the specific need. If the need is only images, basic image processing tools along with video editing tools suffice.

For more advanced uses which have captivating effects, more tools are required. Let us reconsider the case of projection on a cube with an edge-length of 2 meters. It is difficult to simply imagine a sequence which would look good on the cube without actually testing it. Let us not forget that the orientation of the cube matters – it may be kept on one of its sides or tilted on an edge or be placed on one of the corners. The variety of options depend on the projection surface and its complexity.

In such cases a 3D modelling and animation software can prove immensely useful. Most such software can simulate any 3D environment and allow the designer to find out the best image sequences. They are also useful when experimentation space is not large enough. Since the software can produce animation with 3D objects, they can also help in generation of the actual light sequence to be projected. 3D animation software in non-interactive projection based AR can serve as a WYSIWYG tool for the result.

Interactive AR

In cases where projection based AR is used for interactive purposes, the target surfaces are mostly planar and the projection is not a light sequence that needs to be designed with a video editor or 3D animation tool well before

an event; instead it is produced via software in real-time. For the interaction to happen, at least a basic recognition system needs to be in place. The most important piece of technology which brings life to the augmentation depends on recognition systems, which we would learn about in a short while.

Location based AR

Next in line in terms of technical complexity is the location based AR. There are multiple factors at play. Location based AR apps take inputs from various sources. The information sources typically include:

- ▶ **GPS** - It allows the app to pinpoint the location of the device.
- ▶ **Acceleration sensor** - to find out how much you moved and in which direction. This prediction allows the app to update the view before the GPS data is received. Also, since accuracy of GPS is limited by approximately a couple of meters, it serves you when you move below that threshold.
- ▶ **Compass** - To tell the direction you are looking in.
- ▶ **Orientation sensor** - It tells the application how much the device is tilted. This helps predict the angle of view from the ground or in other terms, it helps figure out the location and angle of horizon relative to the device camera.

The application helps locate points of interest on your screen by performing the following steps:

- 1 Depending on the location received by the GPS system, the app requests its server to send a list of points-of-interest nearby along with their coordinates.
- 2 It then reads the direction you are looking in (from the compass) and the angle at which you are looking.
- 3 Combining these two pieces of information, it loads the data about the points-of-interest that it received from the server and overlays it on the camera view.

May we remind again that most location based AR apps do not understand what they see – they do not recognize the buildings and mountains (or anything at all). All they do is to calculate your view relative to other points in your surroundings and place them on the screen.

Trigonometry is what puts it all together. The role of AR application is simple – it has to place the information overlay at the correct places. The accuracy of a location based AR app depends on the accuracy of data received from different sensors. If the GPS data is not available, location

based AR apps cannot work properly. At the same time, an error in any other sensor would result in a shift of the augmentation layer (depending of what has gone kaput).

Recognition based AR

This is the most interesting breed on the list. The technologies that form the base here can aid other AR implementations. It also happens to be the most researched area for the same reason. Technologies involved in recognition based AR are as vivid as the use-cases. Recognition based AR depends on semantic understanding of the object in front of the camera and then replacing it with another object on the output display, or overlaying extra information related to the object.

The multidimensional usage of recognition systems involve various disciplines and quite a significant part of that (if not all) is useful for AR. Before we start off, it would be good to keep in mind that not all technologies pertaining to recognition systems apply to a single recognition based AR implementation.

Image registration

Image registration is a process of merging different sets of data of the same object into one image. The different data sets can be different images of the same object taken at different times, from different angles and may include data received from other sources such as infrared view. When these different sets of data are merged into one, it may reveal a number of attributes which are not visible normally.

The process of registration involves more than one images. One of the images is called the target image and



The process of Image Registration allows the faint mountain range in the background to be recognised

the other as reference image. During the registration process, the target image is transformed in a way that it aligns with the reference image. The transformation can be done in multiple ways, for each of them are best suited to certain types of images. The registration process can try to align target and reference images based on quite a number of registration methods. Some are:

- 1 **Intensity based:** When entire portions of images can be matched.
- 2 **Feature based:** When particular parts of images such as lines, contours etc can be matched.
- 3 **Transformations based:** Rotated or scaled versions of images.
- 4 **Multi-modality based:** When images produced by different types of sensors are joined together.

NOTE

On these pages, by the word 'image', we are not referring to just the ones which we take from a camera. An image produced by a radar would not contain all the colors human eye can see but in terms of computing would still qualify as an image. Computers treat images as a map of pixels where each pixel contains some data. In case of a normal image (the ones we can take from a mobile camera), pixels contain color-data and in case of radar, pixels can be used to represent the distance of the point from the radar. Since such data can be expressed as a visible map, data received from a radar system can be used for image registration.

The above list of registration methods is not exhaustive and there are many which are given a name by combining more than one of them. e.g. spatial registration method involves intensity, feature as well as transformation based methods at the same time.

All these methods of image registrations are imperfect. Though one of the prime concerns of image registration is to reduce errors. An error in matching the patterns in the received images can result in the target image overlaid on the reference image with a planar difference between two points which represent the same part of image (it would be appear as if a displaced layer of the same image has been put over the actual one).

Right from merging more than one images of the same object to showing more than one object on screen, this technology plays a role in recognition based AR. If the images received from more than one sensors are not merged properly, the application fails to serve its purpose.

Object recognition

It is very difficult for a person for look at a washing machine and confuse it with a television. Though humans can recognize a large number of objects easily, the recognition techniques are in their infancy for computers. Object recognition has its roots in artificial

intelligence, pattern recognition and is also one of the driving factors for the image registration process. Interestingly enough the technology has been imagined repeatedly by filmmakers, right from *The Terminator* to *Transformers*.

Most object recognition methods heavily depend on objects that are already known. The larger the number of objects known to the system, better the chances of a correct object recognition. Let us first have a closer look at what recognition methods can act as hints in forming the complete understanding of the object. We would start with simple detection techniques and advance as we move forward.



Remember how Terminator recognised objects such as guns and even the jacket sizes

Looking for gradients

Any curved surface reflects light as gradients as reflection varies in a continuous fashion across the surface. The gradient produced by a cylindrical object is different from that of a conical object. Observing images received via the camera to study the gradients helps in figuring out the overall structure of the object. The variation of gradients based on the lighting conditions for each type of shape which build the object altogether pose a major challenge here.

Comparing grayscale versions

Grayscale versions of images are easier to compare than the colored versions. Think of it like this: pictures of an pencil box when taken under green light looks different than picture of the same pencil box taken in blue light. But when you convert both the images into grayscale (i.e. black and white) the pictures do not look that much different. While to the human eye, the difference is trivial even in color, it makes a significant difference to a computer-based algorithm.

Looking for edges

If you have used any sophisticated image editing program (such as Photoshop, GIMP, Paint.NET etc), you would know of an effect which highlights edges in the pictures. A similar approach serves really well in detecting



The process of detecting line of sight

objects. Unlike gradients which vary under lighting conditions, edges do not. In most normal lighting conditions, location and size of edges do not change.

Comparing the edges in the image received via the camera with entries in the database of images with similar

edge patterns can reveal the nature of object. For example, the edge patterns of a table are going to be different than that of a chair. Change in the position of viewing angle however requires that the edge templates of known objects should also be available from various angles.

Search in large databases of object models

This is more like an exhaustive search which would be done on a large set of object models. In this method, the image is submitted for a search in a database which contains the models for various objects from multiple angles. This method is synonymous to the exhaustive search method in other realms of data management and processing.

Feature interpretation search

If you aren't clear with data structure concepts yet, this might not make much sense. In this method, first of all, features are searched for in the image e.g. search for a 'window', a 'door' and a 'chimney outlet' in a picture of a 'house' should yield hits. Thereafter, comparisons are run for the identical placements of such features in the database of known objects. In our example, the object might just get recognized as a house. The search is done on the nodes of a feature tree. The root node of this tree is kept empty (indicating that no feature was matched). All child nodes in the tree contain all features found in the parent plus one more. As more and more shapes are found, the traversal goes down the tree to find the correct feature set identified in the image.

It is notable that features can be built by nested patterns. e.g. A window can be rectangular in shape with two rectangular panes. If each pane contains a circle drawn over it for decorative purposes, then the windows can be identified as a rectangle made of two rectangles with a circle inside each. In such cases the successful recognition of the window would depend on the algorithm and the nodes available in the feature search tree.

Yet another hurdle in this case is the size and relative position of other objects. Suppose that the feature interpretation based search has confirmed that the object in front of the camera is a house but it also identifies a shoe in the image which happens to be larger than the house itself, then such a match would suggest that the house is actually a toy kept besides a real shoe. For the recognition algorithm to correctly peg this, it would require more than feature interpretation.

WHAT IS A FEATURE?

A feature, in terms of object recognition is a shape identifiable in a picture. Basic shapes (such as a rectangle, square, pentagon, circle etc.) too qualify as features. As you combine more than one feature together, you get more complex ones. In our case, a window is a feature and it is built by rectangles placed inside other rectangles. The identification of a feature depends on pattern recognition. can be used for image registration.

Hypothesization and testing

In this technique, various features are detected in the image first. The list of features are then searched against the list of features in known object models. The overall location of the features is also sent as a parameter for search. From the resulting set, the object model is then projected in software to decide whether the projection of the object returned as a search result would look similar to what is being seen by the camera. If the hypothetical image (projection of the object model received as a search result) is sufficiently similar to the image as seen by the camera, then the hypothesis is accepted and the object is recognised as the one received in search results.

Scale Invariant Feature Transformation (SIFT)

SIFT works by first storing key points (features) of an object and storing them in a database. This is done before SIFT is employed for object recognitions.

When the object has to be recognized, the features are detected along with their positions and alignments and searched in the database.

Invariance

This technique applies to those properties of an object which are not subject to a change with the position of camera being changed. The condition applies mostly to images of planar objects.

There are a few other recognition techniques such as Geometric Hashing, Pose clustering, and Speed Up Robust Features (SURF). Unfortunately their understanding requires some complex mathematical theories which we cannot go in for the purposes of this FastTrack.

Challenges of Object Recognition

The biggest challenge in Object Recognition happens to be the wide array of possibilities available during the pattern search. In all the techniques we mentioned, a database with all the known object models is needed. However a database of object models of one technique do not serve well for others. For example, the database for searching through features in an image will be different from the one which uses grayscale images for comparison.

Databases would again have to store the images of different objects from different angles in various formats for supporting more than one type of algorithm for pattern matching. While it increases the time taken for object recognition, it improves the accuracy and brings down the probability of error because none of the techniques are deemed perfect.

Further difficulty is posed by the requirement to identify partly visible objects. Going back to our case of detecting a house - from some viewpoints, it is possible to achieve only limited visibility of the house - e.g. if you look at a house from the window of another house, you may get only limited visibility of the object. When the visibility of an object is obstructed, identification becomes more difficult. For this, the comparison algorithm sitting between the camera and object database has to be more clever.

In many cases when more than one objects are present in front of the camera, one object would obstruct the view of another. Under such circumstances, it is needed to detect both objects and figure out which object is obstructing the view of another. The simple method for such comparisons is to see which object provides a non-obstructing (complete) view and which one does not. Adding more objects in the mix may eventually bring out an erratic behavior from the algorithm.

Interpreting the video feed

It is one thing to recognize an object and it is another to keep recognizing multiple objects multiple times every second when more can appear any time and current ones can disappear, move and rotate. Object recognition, although forms the base of the recognition based AR, it is still half the story told. The other half lies in interpreting the video feed.

Videos are constructed by taking pictures at a very fast rate. For a video to be watchable, it should exceed the rate of 25 frames per second. Translate this requirement for AR application and it means that the application should not take more than 1/25th of a second to identify objects. The creation of augmentation layer must also take place within the same time frame.

The constraints call in for innovation of better hardware as well as more efficient algorithms at all levels. Ideally an algorithm using dedicated graphics hardware can do pattern recognition at a much faster rate than a completely CPU based algorithm. One method used for recognition based AR is to identify the object once and track its movement as it happens. The comparison of previous image frame with current one can suggest displacement and rotation of objects. In many cases a 3D wireframe model is present within the application to make the comparison which helps understand the differences better.

Building 3D models

By now, it would be obvious that a large part of recognition based AR implementation depends on the 3D models of objects. Building a sufficiently large database of object data is required to provide a better AR experience. While images are easier to insert (all you need to do is to take pictures), 3D models can be difficult. One needs to design the model of the object before it could be fed into the database. Sure, there are tools available for the job. But the variation of design for even simple objects would lead to an enormous number of models. Modelling all of that into 3D is a daunting task. However with tools such as VideoTrace (<http://punchcard.com.au/>), the amount of effort reduces.

Together all these technologies and methods help in recognising the object that lies in front of the camera. Recognising the object is the core need of recognition based AR. The second part - overlaying the object with another object or presenting extra information about the object is easier. It involves creating a transparent layer on top of the actual view and then filling it with required information.

Detecting the line of vision

This technique needs special kind of scanners or algorithm based cameras to track eye movement. It can be used for both augmented as well as virtual reality systems in various purposes. Detecting the line of vision can help relocate the augmentation layer on the right position. This is especially useful when the user is completely placed in the augmented space. This can include both HMDs and car windscreens. While in case of HMDs, the



The outline allows this object to be recognised by the algorithm as a car

entire visible area can be augmented, a car windscreen would cover most of the visible space. Tracking the line of vision can help locate important information right in front of the eye rather than at a fixed location.

So there you have it. To recap you have seen how the augmentation process takes place. The application pinpoints where it is, considers the angle, orientation, direction and recognises what it's looking at based on various

techniques described above. It then overlays information about what it recognises to complete the augmentation process. Brilliant isn't it? And what kind of wondrous applications can this result into? Check out the next chapter. 

CHAPTER #7



30 BEST AR APPS FOR YOUR MOBILE DEVICE

From translation utilities to apps that let you find your car – we cover the best Augmented Reality apps out there

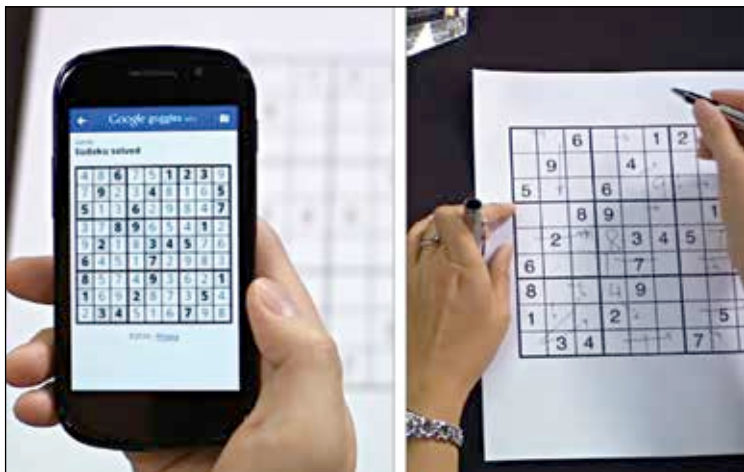
Augmented Reality apps have been available for smartphones and tablets for quite a while now. By using your device's camera, GPS and other sensors, the image through your camera is overlaid with additional bits of information. Below are a few AR apps that you'd like to check out.

1. Google Goggles

Price: Free

Platform: Android, iOS 4.0

This amazing app from Google uses image recognition technology that lets you pull up information about various landmarks, logos, and texts, from the search engine mogul. The app lets you scan barcodes, add contacts via business cards, read book summaries by scanning the title, and returns information about pretty much anything – all by taking its picture. It can even translate the text, or look up the Metropolitan Museum of Arts' website for information on famous artwork. The power of Google's search engine combined with your camera! We don't expect you to return someone's wallet by recognizing a monastery, but it'll definitely help you in all walks of life. And yes, it solves your Sudoku puzzles!



2. Acrossair

Price: Free

Platform: iOS

Acrossair is an AR browser for your iPhone and iPad that works as an awesome 3D navigator to help you reach the place of your choice seamlessly. If you hold your device horizontally, it switches to Google Maps view to indicate your location. You can even pin your location to find your car. You can spin it around and view hotels, cinemas, landmarks and other geotagged entries in your vicinity. With integrated Facebook, Twitter and Flickr, you



can share pictures and location directly from your browser. After you've chosen the category of places you want to look up a.k.a layer, just hold your phone upright and you'll see see-through image balloons floating around your screen overlaying information on the picture from your camera.

3. iOnRoad Augmented Driving Lite

Price: Free

Platform: Android, iOS

This app is your road guardian. Most smartphones would help you navi-



gate while on a road trip, but iOnRoad has so much more to it. It uses your phone's camera, GPS and other sensors to prevent collision with vehicles in front of you by monitoring the headway distance. As soon as it detects that you're moving too close to another car, or if you get off the road, it generates an audio-visual warning to help you take preventive action. It automatically detects that you're parked and helps you get back to your car. It's the ultimate on-road safety app; it was the best augmented reality app in 2011. So mount it on your windshield, and it'll start automatically as you move.

4. Google Sky Map

Price: Free

Platform: Android

So you're walking hand-in-hand with your girlfriend on a starry night, and she asks "Is that Ursa Major?". Don't be baffled my friend. Your guide to the galaxy is right there in your pocket. Just point your smartphone's camera towards the sky, and this app will tell you all about that constellation in view. Move your camera around, and the stars will move with you. Not literally! Point to anything in the sky, and this app will tell you all about it. How about you learn a little by yourself first, and show it off later?

5. Augmented Car Finder

Price: Free

Platform: iOS

Yes it is very annoying when you are in a hurry, and you just can't find your car in the parking lot. Every car seems the same at that time. This nifty app comes to your rescue. Like the name suggests, it's a car finder. As long as you're sober enough to use your i-device, this app will take you right to your car's door. Wondering what's "augmented" about it? When you launch this app, it uses your camera and gives you directions to where you placed your car. It also tells you the street address closest to your present location.

6. AR Invaders

Price: \$1.99(iOS), \$2.42(Android)

Platform: iOS, Android

This one's for the Independence Day experience. Charge on like Will Smith and shoot the aliens. Everything around you turns into a warzone with this

app. Blast space invaders with your smartphones; stand up and fight in 360 mode, or sit down for 180 mode. You can even recruit an army with your friends in multiplayer mode. Stand up and fight for Earth, because these aliens are everywhere you point your smartphone.



7. Theodolite

Price: \$3.99

Platform: iOS



Are you one of those people who want to know the altitude, temperature and other geographical features of every place? You're in luck! This app is great for adventurers, architects, engineers and

search and rescue guys. It gives you the topographical scenario of your surroundings, overlaying the information on the image from your smartphone/tablet's camera. It even lets you learn your elevation, inclination; it works as a compass, GPS, and a range-finder. So the next time you go hiking, this app will come in handy.

8. Wikitude World Browser

Price: Free

Platform:

Android, iOS, bada, BlackBerry, Windows Phone

Wikitude is your smartphone's AR encyclopedia. Use your smartphone/



tablet's camera, hold it up and look at your surroundings. You'll see the world through it's eyes. Get information on restaurants, landmarks and other places. Organize your "worlds"(content providers) according to your preference. Find ATMs, hotels or restaurants with your favourite cuisine from Yelp, Qype, TripAdvisor and Hotels.com. The Wikitude World Browser has been voted "Best Augmented Reality browser" three years in a row: 2009, 2010 and 2011.



9. Lookator

Price: Free

Platform: Android

Launch this app, and see through the camera; you'll see WiFi hotspots with their relative strength and direction. The directions may not lead you to the hotspots, but it will definitely get you a better signal.

10. TagWhat

Price: FREE

Platform: iOS, Android

Still carrying brochures for every place you visit in the holidays? No more flipping through pages looking up every landmark you encounter. TagWhat does all the work for you. It uses your smartphone's camera and GPS, and pulls up information from



the web and social networks about everything in your vicinity. It's the ultimate tour guide. Read reviews, related stories and post your feedback. Sharing is what it's all about.

11. Satellite AR

Price: Free

Platform: Android

You might not be an astronaut, but if you're interested in knowing what

satellites are flying overhead, we have just the thing for you! Point the camera up in the sky, and little icons will show you all the satellites in the view. Just tap on the icon to know more about that particular satellite. Who said you need to work at NASA to know about extraterrestrial objects? You just need your Android device.



12. Layar

Price: FREE

Platform: iOS, Android, BlackBerry



Layar is another AR browser for your smart-phone/tablet. So easy to find services near you anytime, anywhere. This app even displays tweets from nearby areas. Use your phone's camera to scan any restaurant, building or even a corner around the street,

and Layar will get you over 3000 layers of digital information to choose from. Scan your magazine and “make the print world clickable”. Save your favourites and share over the web.

13. SpecTrek

Price: \$2.49

Platform: Android

Bored of sitting indoors with all your gadgets? Take this app outside, and “hunt virtual ghosts in the real world!” SpecTrek is a fun app for children, that requires a lot of physical exercise. Scary ghosts appear in your surroundings(or in



the smartphone's view of your place); you need to run towards them and shoot them with a net. The app provides bonuses, titles and records; basically the drive to keep you moving. And if you're a grown up but you don't believe in growing up, here, go nuts!



14. SpotCrime

Price: \$2.99

Platform: iOS

This app by spotcrime.com keeps track of all the crimes near you or anywhere else. It uses your iPhone's GPS to tell you if you're taking a safe street. It shows you criminal records / occurrences in the vicinity with different coloured icons. Point the camera towards a

street, and check if it's safe before you take the wrong route. It's really useful in North America, but more areas are being covered worldwide.

15. 3D Compass+ (AR Compass)

Price: Free

Platform: Android

It's a traveller's tool. It has got navigation maps, a compass and local business finder apps all integrated into this one nifty application for your



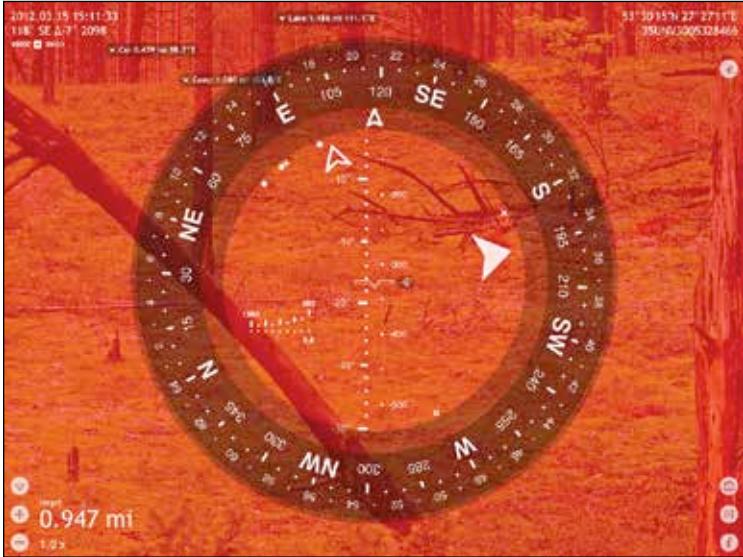
Android device. If that weren't enough, it comes with an augmented reality view using your device's camera. It overlays a compass on the image from the camera, and leads you in the right direction. There is also a map on your screen which helps you navigate. Turn up the brightness directly from it for better viewing in sunlight.

16. Spyglass

Price: \$4

Platform: iOS

This is another amazing augmented reality compass for your iPhone/iPad. It has got everything you'll need if you're ever lost in a jungle or hiking up a mountain-milspec compass, gyrocompass, speedometer, sextant, inclinometer, angular calculator. It uses the GPS of your device to track your



location in both geo and military formats. You can even save your location's coordinates for coming back to it later. It's even got an optical rangefinder that measures distance between you and an object in sight. Navigate by tracking positions of the Sun, the Moon and stars. Everything operates in an augmented reality view in 3D space at any orientation. A must have for adventurers.

17. Augmented Colors

Price: \$0.99

Platform: Windows Phone 7, 8

Ever think of catching a butterfly in a jar, and to keep all the pretty colors? Now you can use your Windows Phone's camera to pick and save colours.

This app is useful for artists and graphic designers. It identifies the RGB and hex values of a colour and stores the colour code to be used elsewhere. Just get the targeted colour between the crosshairs, and the screen and pin it on a live tile. A colour picker for real life!



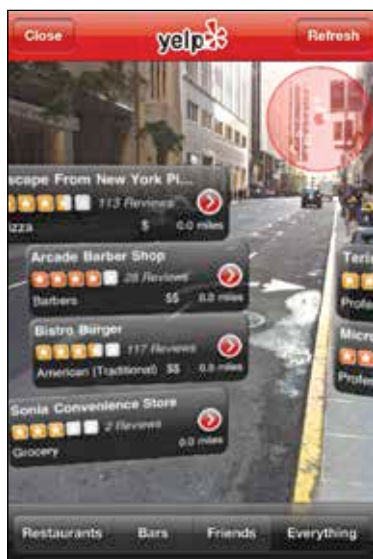
18. Yelp

Price: Free

Platform: Android, iOS

Need help? Ask Yelp! Sounds cheesy, but it's true. Yelp is your guide. Need a place to stay, or want to eat Thai food and you're lost in the new city, Yelp

will help you find anything anywhere. Custom search allows you to narrow the choices by category—cuisine, distance, what's open now. The Yelp Monocle uses augmented reality to overlay information on the image from your smartphone's camera. Shake your iPhone three times to launch this app. Browse through the reviews and ratings by fellow travellers and post your feedback.



19. AugSatNav

Price: Free

Platform: Android

This is the augmented reality version of Google Maps which overlays walking directions

upon your smartphone's camera feed of the path/road ahead. No need to zoom in and out of complicated maps, just follow the highlighted white



light on the screen and it'll lead you to your destination. If you're at crossroads, and don't know which side to go, the app will show an arrow to the right direction. No more asking strangers on road for directions.

20. ARBasketball

Price: Free

Platform: iOS

Bored at work? Now all you need is your i-device and a small piece of paper to play basketball. Well, it's not as easy as throwing the ball into an actual hoop, but it's pretty fun once you get a hold of it's technique, and addictive too! Print the marker on a white paper from http://simiotica.com/arb_marker.pdf and point your phone's camera at it to see a hoop. Swipe your finger up over the screen to throw the ball. An actual hoop doesn't seem so cool now, does it? Another similar but amazing app, ARSoccer(\$2), let's you play soccer. Just point your phone's camera at the ground, and use your own feet to kick the virtual ball.



21. Sun Seeker

Price: \$8.99

Platform: iOS

Sun-lovers, find the Sun anywhere, anytime! Yes, it may seem a little steep but it's not just about the Sun's location. The app shows you an augmented reality view of the solar path, it's rise and set times, and a map view showing solar direction and elevations for each daylight hour of any day of the year.

This app is great for photographers, gardeners, architects and even real-estate agents. Find the sun exposure of your property and optimal light conditions for your lobby and construct your house accordingly.



22. Paintball

Price: Free

Platform: Android

Another amazing game on your Android device—real-time paintball in augmented reality. Choose from a variety of stunning paintball guns



and play this awesome action-packed game against your friends. Just like the actual paintball game, this is also meant to be played with your friends. So connect via WiFi and “Ricochet, you take your aim... Fire away, fire away!” Specify the colour of your enemies t-shirt, play in well-lit areas and shake your phone to reload. Watch your back, your screen flashes and vibrates when you’re hit.

23. Augment

Price: Free

Platform: Android



Augment lets you visualise 3D objects such as paintings, books, furniture or even characters in your surroundings using your Android device’s camera. Fill your room with augmented objects. Try a new setting without actually rearranging everything. In order to use this app, print the marker

from <http://augmentedev.com/markers.html>. Then, select any 3D model from the gallery, aim your camera at the marker and voila! You will see the object in place of the marker on your device's screen. Have fun creating your own 3D characters and objects.

24. GeoGoggle

Price: Free

Platform: Android

This app lets you know the geographic details of your location: latitude, longitude, altitude in augmented reality. Also check your speed as well as the distance to a specified location. It tells you directions using a 3D compass. Take photos while on the go, and use the map to see all the places where you clicked pictures. Use this app in conjunction with c:geo for mobile geocaching. Too many utilities, all packed into this one nifty app with a user friendly interface.



25. Kafkara Augmented Reality

Price: Free

Platform: Android

Create talking avatars from your friends' faces in augmented reality. Avatars can be created from the image from your camera. Create avatars from Facebook and Twitter profile pictures which then speak their latest status updates using text-to-speech technology. Interestingly, the app's name is derived from the famous Franz Kafka novel 'The Metamorphosis' where a man wakes up in the body of a beetle. Various bodies to choose from for your animated avatar. Now if you have a grudge against someone, or you just want to have fun, choose the funniest and creepiest of all the avatars.

26. Junaio

Price: Free

Platform: Android, iOS

Another augmented reality browser, it helps you locate theatres, restaurants, taxi station all right in front of you. There's also a barcode and QR code scanner in this app, so you get instant product information. Not as



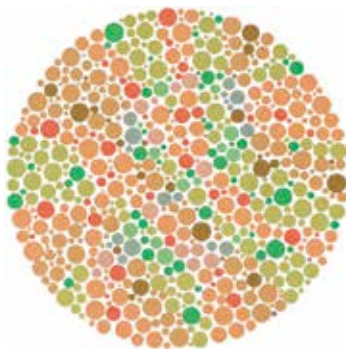
many layers as in Layar, a good app nonetheless. It integrates various apps like Twitter, Wikipedia, Foursquare, Instagram to get updates on your favourite content all in one application.

27. Color Blindness Simulator

Price: Free

Platform: Android

This clever app simulates the vision of a color blind person. When you view an object through this app using the camera of your smartphone, it generates two images: one that a normal person would see, and another version of it that an unfortunate color blind person would perceive. All common types of colour blindness are supported- dyschromatopsia, protanopia (red color blind), deuteranopia (green colorblind), tritanopia (blue color blind) and more. You can test your own vision by comparing both the views. So if you have a friend who's color blind, you'll can see the world from his eyes.



28. Nokia City Lens

Price: Free

Platform: Nokia Lumia Windows Phone 7 and higher

This is the augmented reality browser for your Nokia smartphones with Windows Phone 7 or higher. You can download it from Nokia Beta Labs on your device. This is a great location based app, which helps you look up places in your surroundings by overlaying information on the camera feed of your smartphone. Now you needn't look down upon your camera and use Nokia maps for navigation. All you need to do hold your phone upwards and see the magic! You can instantly see restaurants, bus stations, hotels; filter your search by category. It's pretty, it's useful, it's to die for.



29. Peaks

Price: \$3

Platform: iOS

When you travel, you come across mountain ranges, ever wondered “Which mountain is that?” But no one seems to know the correct answer. The answer to these questions is here. This amazing app by



Augmented Outdoors tells you everything about a mountain (major or minor). Just point your iPhone towards it, and it will do the rest. It'll also tell you the mountain's altitude and how far away it is from you. Click pictures with or without the overlaid information- double-touch a location bubble to make it disappear. On top of that, you don't need an internet connection for this app to function. It works offline! Can it get any better?

30. DishPointer

Price: \$9.99

Platform: iOS

Just like the SatelliteAR for Android devices, we have DishPointer for iPhone/iPad users. Like always you have to pay a little extra for services on your i-device; but what you get, is just worth it. This beautiful app is the

ultimate satellite finder. Point your phone towards the sky and see on the live camera screen where the satellites are located. It was never easier to set up a satellite dish. Invaluable for campers. Adding to the list of amazing features, it does not even need cell reception or an internet connection.



So far we've covered 30 cool AR apps that you should check out! There are many more such applications which are now switching over to augmented reality for a better and more beautiful user interface. The technology is moving on, and so should you! 📱



CODING FOR AR - AN INTRODUCTION

AR programming is neither just about mathematics nor just about code. There are hurdles and we are here to help you take a jump into creating AR apps

AR is magic to some, but magicians know that all magic is science. In this chapter we introduce you to the wands which build a magical layer on top of reality.

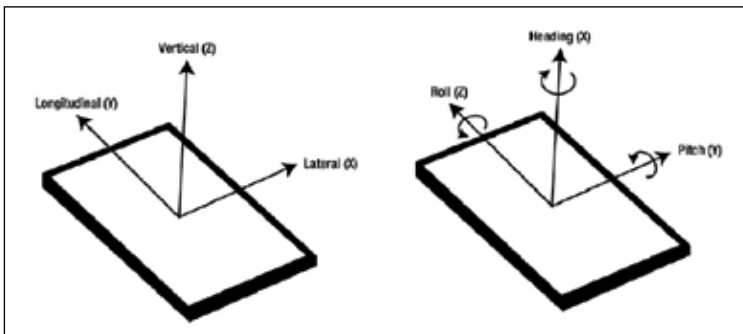
Concepts and Domains Involved

Augmented reality does not derive itself from a single engineering stream but many. It requires one to understand more than one technology at a time. Development of AR apps may require enormous amounts of effort depending on the type of development that needs be done. As much as it is true for any other type of application development, more critical the application, more testing and accuracy is required (a military application has to be much more fast, secure and precise than a traveller's AR browser application). We have seen the types of augmented reality in previous chapters. In this one, we walk through the domain knowledge required by each of them.

Location based AR

Location based Augmented Reality is one of the easiest to program for obvious reasons - you would have all the resources required by you in the form of Android or iPhone (iOS) SDKs along with the device itself. The requirement here is to understand how to fetch data from sensors and use it to produce desired results. In most cases the APIs would provide you data in usable format but that would still be incomplete without in-depth understanding of what you are fetching.

In addition to this, you are in need of understanding GPS system and its limitations. If you are unclear about the Latitude and Longitude systems,



It is important to understand the roles of Orientation Sensor and Accelerometer for creating a Location based AR app

you need to brush up your high-school geography before you would be able to develop location based AR apps.

Projection Based AR

This one is more difficult to code for than location based applications. Projection based AR depends on three main factors – the surface on which projection has to be done, the light sequence to be projected and position of the projector. One point of projection based AR is that both development and implementation of an app is more expensive than a location based AR app. You are in need of an intelligent enough video editor (unless of course, you plan to project a static image), a powerful enough computer to help you with the job, a nice projector and a setup which allows you enough space to experiment. A few points which are worth a note about projection based AR:

- 1 You will always need a low-light situation for projection based AR to work.
- 2 You need enough space to develop the light sequence for projection. e.g. If you want to project your light sequence on a cube with an edge of 2 meter, kept at a distance of 8 meters from the projector, then developing the light sequence by using a dice as a reference surface is a bad idea. Ideally, the target object's size on which the simulation/testing has to be done should be the same as the target; but in case that cannot be done right away, the target object should still be large enough. It helps remove errors and allows better inspection during development.

- 3 Projector resolution matters. You cannot use low resolution projectors built for PowerPoint presentations in a video sequence on a concert stage.

When we talk about the domain of knowledge and experience required to undertake a projection based AR app, the skillset required is more mathematical than programmatic. Once again, it would depend on the specific application.

- 1 If you are planning to use projection based AR in a concert, then the skillset required is going to be almost purely creative. There is hardly any programming involved except the tool which would help generate the light sequence.
- 2 If you wanted to build a dialer on your palm, you would be in need of basic projection system (which would be probably mounted on your head) and a recognition system clever enough to understand what you are touching with your finger. In this case, you are more in need of image

recognition skills which again is a blend of various technologies and spans multiple research streams.

Recognition based AR

Recognition based AR depends heavily on pattern recognitions. More your app knows about patterns, more it can do. Pattern recognition technology has developed in leaps and bounds in the last half decade. Smile shot, face recognition for tagging and Google's 'Search by image' feature are some of the most famous applications of image recognition technology. But this is nowhere close to completion.

The first place from where you can start off with recognition based AR development is, once again, your smartphone because it already comes with the features of pattern recognition. Every time you scan a QR code to install an app, to open a webpage, you employ the pattern recognition faculties of your phone. But your phone can only get good enough for basic pattern recognition. If you want it to do advanced 3D object recognition, it might not prove to be the best gadget.



QR code scanning depends on pattern recognition

3D object recognition requires much more data, processing power and efficient algorithms for getting the job done. While data can be stored on a phone and algorithms be designed for the same, phones

cannot have very powerful processors. Coming back to 3D object recognition, you would typically be in need of clever image recognition systems which know how an object appears from different angles.

If you have to create an AR application which can recognise objects and then augment a layer on top of it, you are limited by some very basic shapes. For example, a popular development library AndAR (stands for Android Augmented Reality) which allows you to create recognition based AR applications for the Android platform supports only very basic pattern recognitions. Better computer vision and object recognition libraries are available for more powerful systems (such as for desktops and laptops) and with their aid, you can create more intelligent applications. It is easily predictable that in time, with more advanced hardware and software, such libraries will be available for mobiles as well.

From the knowledge domain perspective, recognition based AR requires deep understanding of computer vision and multimedia systems, especially that of video data (augmented reality works with continuous video feed from a camera; simple image recognition systems are not of much use here). Once again, all these disciplines depend on multiple mathematical research fields. If the library you are working with does not provide you with the required features, you are going to need superb mathematical skills to get things to work your way.

Outlining based AR

Outlining based AR heavily depends on object recognition and hence, a significant portion of knowledge required to work with recognition based systems is also applicable to the outlining based AR systems. However the game is not all the same. Outlining based AR applications may use data sources from other sensors too, such as compass, GPS, accelerometers, ultrasound sensors, infrared sensors and so on. Depending on the requirements of the particular application you want to develop, conceptual and domain knowledge of one or more of the above will be necessary.

Software required

Let us say you want to build a location based AR browser. To achieve the feat, you need to plan first and for that, you would need answers to a few questions. We try to show you some which you would most certainly have to face:

► What platform should I build it for?

If you are using an Android phone, you would target android; if you are an iPhone user, it'd be iOS. If you want to build a commercial application, you would want to target them both and may be others too, such as Blackberry and Windows Phones. The target platform depends on who your users are and need you wish to fulfil.

► What programming languages can I use?

That would depend on the platform that you are targeting. If you want Android, you need Java. Objective C if it's for the iPhone while Windows and Blackberry phones allow you to get creative with multiple languages.

► What OS can I use as a development platform?

Once again, it depends on your target platform. Windows phone apps

need Windows for your development environment. Android apps can be developed on any platform where Java JDK works well. iOS development demands that you have a Macintosh with Xcode installed.

► What IDE should I use?

Windows Phone asks for Visual Studio and iOS asks for XCode. Android being based on Java, can do with any IDE as long as you are able to compile the sources and generate an APK package. Ideally Eclipse is the IDE used by most but other IDEs with more features (such as IntelliJ Idea) too support Android SDKs.

► How much help would I get on the web?

iOS and Android cover majority of smartphone market and thus the help available on the web for one of these platforms is more than other platforms. Almost all platforms have well documented APIs which would help you as you progress.

► How much time is it going to take?

If you were to just throw the geographical coordinates on the user's screen, it would not take much time (and that does not count as AR). But if you were to include a map and an object recognition system right into your AR browser app, then you are going to have your hands dirty with code for a longer time. It would also depend on what your experience has been as a developer for your target platform.

As you can see, there are multiple variables in the mix and the most important factor which is going to affect your decision is the platform you want to target. Depending on the platform you want to build your app for, you



Android NDK can be used to run platform specific code

have several restrictions. As a side note, one of the biggest reasons Android wins the apps battle is the freedom of options it provides except in terms of programming language.

In all cases nonetheless, you are in need of the platform SDKs. In case of Android, you have a sepa-

rate NDK (Native Development Kit) which allows you to write native code for the target platform (remember that Android can be made to run on an Intel machine as well, while most mobile phones run on the ARM platform). The NDK compiles code to binary for the native platform. If you are going to program games which need OpenGL, you would need NDK in most cases to leverage the hardware capabilities.

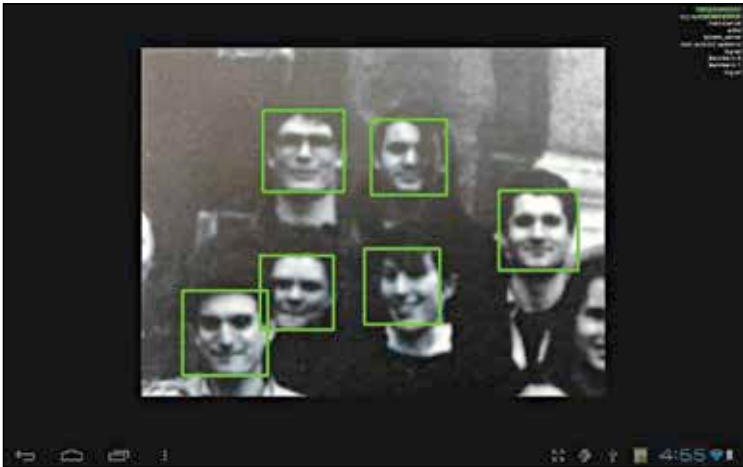
What frameworks do I have to aid me?

It goes without saying that frameworks are built around a particular language (the only exception to this would be *.NET* framework which supports multiple languages). You can neither use CodeIgniter for creating a Java based app nor Qt framework for writing a Python script. We have already mentioned that the choice of language, IDE, development platform etc depend on the target platform. This translates to frameworks being mutually exclusive for mobile platforms. In addition to this, frameworks which need to run on the mobile platform have to use the platform specific APIs. This shrinks the possibility to have cross-platform frameworks for AR uses. Here we list out the most popular and useful frameworks available to ease up the process of building AR apps.

OpenCV

A list of libraries which could help you do AR would be incomplete without OpenCV. OpenCV stands for Open Source Computer Vision and is one of the most famous libraries in the computer vision field. In case you are unaware, computer vision is the field of study which deals with any and every topic methods of acquiring, extracting, analyzing and understanding information from images to help a computer for take decisions in real world. Object recognition technologies come under the umbrella of computer vision. OpenCV claims to have more than 2500 optimised algorithms for computer vision of which, a majority can be useful in creating recognition based AR apps.

OpenCV can be a great aid to AR programmers because of the language bindings that it offers. OpenCV has interfaces in C, C++ and Python as of now and soon, it would be available for Java as well. Since iOS apps need to be written in objective C, one can utilise OpenCV's faculties by importing the library into the application. The fact that Windows phones can be programmed in multiple languages is a benefit and OpenCV can be used with C++ for Windows phones. As far as Android is concerned, you can use the



Face detection with OpenCV library

NDK (Native Development Kit) to cross compile OpenCV for android. An Android specific port is available at <http://opencv.org/android>. A blackberry port is also available for OpenCV. In case you want to build a desktop based application, OpenCV is compatible with Windows, Linux and Mac.

The most attractive part of OpenCV is the efficiency. Being written in C++ with multithreading support, it runs fast. The API is organized and allows you to perform high level as well as low level functions on the data received. STL based interface is also a blessing. Despite being written in C/C++ OpenCV manages the memory for you. This is a huge benefit for those who are afraid of pointers. OpenCV is licensed under a BSD license which means that it is both open source and free to use. You may use it for an open source project or for a commercial project.

AndAR

AndAR stands for Android Augmented Reality and – as evident from its name – is meant for the Android platform. The project seems a bit old since the official project page (<https://code.google.com/p/andar/>) shows the last release date back in 2010 implemented for Andoid Eclair and Froyo. Since majority of devices now run on Gingerbread which is mostly backward compatible with Froyo, this would still be helpful. AndAR uses the JNI (Java Native Interface) and contains code written in C (ah, the efficiency part) which

means that you would need the NDK, once again, to use it in your application.

AndAR can only detect most basic shapes. You can find AndAR and AndAR Model Viewer apps in the android market and see them in action. The default shape that AndAR recognizes is a small L shape inside a box. Both the box and the shape inside should be of thick lines and black in color. If you wish to, you may create your own markers.



Default AndAR Marker

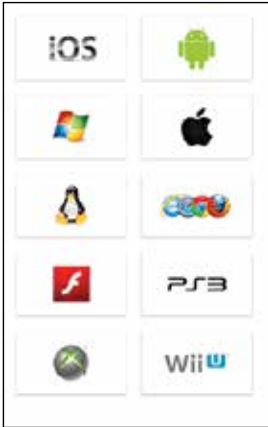
IN2AR

IN2AR (pronounced “Into AR”) is the brainchild of a company called Beyond Reality located in the Netherlands and happens to be a SDK to help you build AR applications. The best part is IN2AD supports Unity. For those who think that Unity is just the UI of Ubuntu Linux, Unity is a game engine available for free at <http://unity3d.com>. The interesting part about Unity is its cross platform nature – it can help you reach 10 platforms: Desktop (Windows, Mac and Linux), Mobile (iOS, Android), Web (Packaged HTML pages, Flash) and Consoles (Wii, PS3 and XBOX 360). Since IN2AR supports unity, building your AR app in Unity will allow you to get cross platform publishing for your app easily enough so you can focus on the main functionality. IN2AR is written in Adobe ActionScript (AS3) and uses Adobe Native Extension Library for platform specific code. To



IN2AR demo page shows the advanced capabilities it comes with

use IN2AR fully you'll need to get the Adobe SDKs as well. The Flash SDK and AIR SDK are similar to each other while it is the Unity SDK which you might get interested in. Unity SDK comes with IN2AR plugins for iOS and Android (along with Windows and Mac).



Unity can deliver on almost every platform

IN2AR is available in two licences - commercial and free. The free license has some restrictions such as added logo on web apps and 90 seconds operation on mobile apps. The commercial license is costly (around \$2600 or Rs. 1,30,000). That is a huge sum if you only want to try and test the platform. If you have an awesome idea revolving around recognition based AR, you can start off with the free version. That said, the Unity engine too has a commercial license which you can avail for an amount (but well, the licensing is pretty flexible here). To understand why this framework in particular carries value, do visit the IN2AR demo page: <http://www.in2ar.com/demo.asp>

Once you have gone through the demo, it is not difficult to see why IN2AR can be a good tool for creating apps like a virtual online dressing room. The Unity SDK makes sure that you can build games around Augmented Reality and publish it to not only mobile platforms but also to desktop gamers. Since IN2AR can detect multiple markers in a video feed, possibilities are high. Do note however that detection of more than one marker needs more processing and the performance would roll down.

Layar

Layar is one of the most famous AR location browsers which allows one to work with layers. You can create your very own layer which marks all the interesting outlets in the locality to help your friends. A food chain store can create one to help

WORTH A TRY?

The Videotrace tool allows you to extract out real life objects and build a 3D model of them. At the same time IN2AR allows easier detection of objects and create AR applications. Combining these two, it might just be possible to create a game/interactive app which merges real world with a virtual one.



Layar Vision recognizes the image fingerprint

users locate their outlets. A company can create one to help users locate their offices and so on. All with minimal effort.

Although Layar has been an AR location browser, a relatively new technology named “Layar Vision” from the company promises to bring a new dimension to advertising and to the print industry. It allows one to upload a picture or a set of pictures to their servers which together form part of a layer. When the user activates the corresponding layer, it readies his/her device for image detection. When the user points the camera towards the image in real world (with the Layar app running and the right layer loaded on the app), Layar Vision recognises the image and shows the content. The content may be an advertisement or promotional offer or a descriptive video or anything that the creator of the layer intended to show for the image. It takes the concept of QR codes and pushes it one step ahead. While QR codes can contain text and web links, Layar Vision can trigger a predefined action. Also, Layar Vision uses an AR layer so it is more interesting than looking at a non-interactive QR code.

Layar APIs depend on REST technology which in turn depends on HTTP (just like majority of other applications). This translates to a lot of help being available on the web. The APIs are documented and you should not find much difficulty using them. Should you find yourself in trouble, quite a long list of posts and entries are available online along with discussion forums where others working on the platform could help you get through your niggles faster.

FLARToolkit

FLARToolkit is based on ARToolkit. The development of original library (ARToolkit) appears to have stopped as the last release was back in 2007. However, FLARToolkit is still breathing and alive. The project is available online at <http://www.libspark.org/>. The website is in Japanese and the only way you can use it well enough is by using Google Translate. There is a discussion forum which is in Japanese too, unfortunately. The library has been utilised in quite a number of programs. If you are willing to use it, the official site may not be very useful (we assume you do not understand Japanese). However, help is available elsewhere by people who have used the library to create their own apps.

Wikitude

Wikitude is an AR based location browser app. As a developer it offers you SDKs for Android, iOS and Blackberry. You can develop apps in one of these or deploy using web technologies (HTML, JavaScript and CSS). There are multiple versions of the SDKs and you have to buy a license for the platform before you can publish the app. Once again, you have documentation and discussion forums to help you with.

FREE TRIAL	SDK LITE	SDK PREMIUM	SDK ULTIMATE
			
Full AR feature set Includes a watermark in a generated reality view. Intended for testing the SDK.	Full AR feature set Includes 10,000 Unique Installs and perfectly fits for small-sized app projects.	Full AR feature set Includes 125,000 Unique Installs and perfectly fits for medium-sized app projects.	Full AR feature set Includes 1,00,000 Unique Installs and perfectly fits for large-sized app projects.
0 €	299 €	999 €	2999 €
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Wikitude SDK is not free enough

To sum it up...

While there is no dearth of frameworks for almost any purpose, it is better to start-off with open source libraries. If you have not programmed an AR application before, the open source nature of the libraries would help you understand the underlying concepts, and guess what, you cannot skip the concepts even if you are using an AR library.

If your aren't targeting a mobile platform, OpenCV is the best bet in the free world, and IN2AR if you are ready to pay. There are many other frameworks and libraries which we have not mentioned because they are either immature or their development has stopped long since. Also, before we end, we would like to emphasise on planning. Most AR applications are being targeted for mobile phones. If you too are going to develop for mobile phones, choose your target platform(s) wisely. Even more importantly, you should choose the framework which is known to work with the platform well enough. If the planned platform (and we do not just mean the OS, the device which you are going to test your application upon matters as well) does not support the technologies, amount of effort needed will rise.

We wish you a very Happy New Year ahead as we sign off.

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